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THE VALUE OF X[1].

BY WILLIAM R. WESTHAFER,
Wooster College, Wooster, Ohio.

$5x+35=70$. Well we remember our first algebra lesson. $5x+35=70$, find the value of x. Well we remember the interest, wonder and final despair with which we gazed upon that first equation. We knew the meaning of the arithmetical signs, we understood the figures, but the presence of a letter where a number should appear was a mystery quite beyond our youthful brain.

And then we remember how, with an explanation by the teacher and a little thinking which was to us along rather a new line, we began to see light and we recall the satisfaction that we felt when at last we grasped the idea and saw that the letter in the equation was a symbol and that it stood for an unknown quantity. Then by allowing it to take the place of that quantity and by proper manipulation, transformation and adjustment of relationships we could evaluate the unknown term and find the value of x. Some of us have hardly recovered from the thrill of that moment yet.

Solving an equation for the value of its unknown quantity or quantities is not only a beautiful and interesting mathematical process but represents a method widely applied in scientific investigations and useful in solving the many problems of life. Finding the value of x is the act of getting results—coming to a satisfactory explanation of something. It is the process of answering a formulated problem.

Many people do not like problems. Constructive thinking is difficult exercise. It is hard work to think. Not long ago I had this experience which has come to be rather a common one during the registration period. A student came to the office to consult with reference to taking a certain course in Physics.

[1]Reprint from the *Wooster Alumni Bulletin.*

Almost immediately he put the question, "Do you give problems in this course?" "Oh, yes, the course is made up of problems. It is a problem course." He lost his interest at once—afraid of a problem. I suppose this student registered for a course in college in which he thought there were no problems. In that he was mistaken. There really are no courses of that kind. What about the problems of Philosophy? Have its conclusions all been accepted? There are problems in History, Economics and Government. And will any one say that there are no unknown quantities going into the building of a language or the making of a literature? It is true that, in many subjects, the problems are not so definitely and accurately stated as in Mathematics and Physics but they are there and one can not escape them by omitting certain courses in college. Life is a problem and if a man thinks, he finds x's all along the way.

You begin to find and recognize unknown quantities early in life. You had x's to solve long before you were assigned an algebra lesson. As the intelligence of a child develops he soon reaches the point where he wants to know about things. Experience has shown that it goes about as follows: the small boy is amusing himself with his new play wagon and suddenly turns to his father and says, "Dad, how do they make wagons?" "Well, they take boards, saw them into pieces of the right size and shape and fasten them together with screws and nails." "Well, dad, how do they make boards?" "They saw the boards out of trees." "How do they make trees?" "Trees grow, my son." "What makes them grow? Why don't telephone poles grow?" "Trees grow because they have life," and then if you are a botanist or a biologist you feel secure and improve the opportunity to enlighten Johnny on the subject of cells and growth. But the next question puts you in deep water—"How do they make life?" However, you proceed bravely to explain how God gives life and then you are through. But the child isn't. He has one more question. You know it is coming and you know you are helpless. "How did they make God?" The child of five years is face to face with the greatest question of all. The mysteries appear early and many of them are never solved.

Henry Ward Beecher, America's pre-eminent preacher, said, "If we knew more of the spirit of nature, we could better understand the nature of the spirit." In these days harsh things are being said about science. Some people maintain that our civilization is top heavy with science. No thinking man believes

that. We are not too scientific. We need more of the scientific attitude.

Now what is the scientific attitude? It is the attitude that was your attitude when you looked upon that first algebra lesson —an attitude of interest, an attitude of wonder, an eager desire to know, a willingness to listen to the teacher, to put things together in logical order and in right relationship and then to accept the results. Many people do not want to accept results. They say science is good, it is a beautiful process, but the results often do not agree with fact. And by fact they mean what they themselves had previously thought about the matter in hand. When we take this attitude we are untrue to the motto—*Scientia et Religio ex Uno Fonte*. The great Author of all did not write one thing in His Book of Nature and then deny it in His Book of Law.

Note that the scientist proceeds with his work in the same innocent, detached way that the scholar goes about the solution of his first equation. Up to the time of Galileo all science was veiled in mystery. This great student had the courage to draw aside the cover and to try to explain things on the basis of physical law, and with him experimental science was born. By the new method facts are collected, equations are formulated, expressing certain relationships between quantities and involving the known and unknown terms. If the equation is correct and the hypotheses true, then the unknown x has a value which may be found. If the test of experiment agrees with the theory upon which the equation was built, we have a physical law. By this method science has grown up, and as a result of this sort of study we have a large amount of evidence which explains the phenomena of nature and helps us to a better understanding of life.

The scientist approaches the study of the world of things with the eager interest of a child. *X*'s appear in all the formula of nature. As x is to the child the thing of interest so to the investigator the unexplained is the thing that attracts his attention. He wants to know for the sake of knowing. Joy comes in the understanding of a hidden process. Practically all of the fundamental discoveries in physical science have been made by the pure scientist, not by the practical engineer. Nature seems to reveal her secrets to the man who wants to know just for the joy of knowing. The thrill comes when he gets to the end of the problem and has the result not because the result will be of practical value to him, but because he has made a new discovery.

Some years ago I put a student on the rather simple experiment which involved the arrangement of apparatus so as to get an electric current from sunlight. When he was ready we went into the laboratory together, closed the switch and allowed the sun's rays to fall in the proper place. Immediately the galvanometer began to swing, indicating that the current had started and the thing was done. It was not at all a difficult thing to do, but revealed one of the most subtle and interesting phenomena in electricity. The boy looked at it a few moments with a smile of deep and uncontrollable joy on his face and then remarked, "Gee, isn't this a great world." He had the spirit. He had what we all ought to have—a real appreciation of the working of this wonderful machine we call nature.

Again, science is not afraid of problems or possible results. It will attempt the solution of any problem. No x is too big for a man's thought. Pure mathematics has given us many methods for the solution of many equations. A single mathematician often gives his life study to the solution of a certain form of equation, often without success. But the pure mathematician does not discriminate. He does not say this problem is legitimate, we may work it, but that one is tabooed. He takes the stand that all correct equations may be solved if we can find the method. Nor is he afraid of results. How often in history we have seen progress blocked because a certain subject was too sacred for investigation.

More than a dozen years ago at a joint meeting of the American Physical Society and the American Mathematical Society the Einstein Theory was first presented to these societies. That was an interesting meeting. It was historic. After the speaker had finished his lecture and placed the strange equations upon the blackboard, the discussion began. It was a debate royal and in point of ardor and intensity would have done credit to a debate in the United States Senate on the tariff. Some one said. "If these equations are correct, no one knows how far it is from New York to Philadelphia and we could not find out by measuring the distance." The speaker replied, "Yes, that is correct." Another suggested that if the theory were true, a second may be as long as time, and again the speaker said, "That is correct." Over in one corner of the room sat a small very old professor of mathematics resting his hands on a cane and a friend who sat near him suggested that, if the conclusions of this theory were accepted, Professor ———— could, if he ran down street

fast enough, achieve a bodily mass equaling that of President Taft. And the speaker answered "Yes, if he ran fast enough." Here was a favorite law of science (the conservation of mass) being attacked, but the interesting thing was that no one became angry. The hypotheses could not be disputed, the mathematics was sound but the conclusions seemed absurd. Here was something new and interesting in human thought apparently changing theories long believed. But note the attitude of those men. They did not say "This is revolutionary and we must stop thinking along such lines." Hardly a man there exressed his belief in the new theory but all were interested. All went home thinking, determined to find out something about this thing which they did not believe in, not to pass a law to stop thought. You can not stop thought or the processes of nature in that way. You can not repeal the law of gravitation by state statute. The people in some states of the south have that to learn yet and some who do not live in the south.

Here is the problem of evolution. With the facts at hand it may be stated in an equation so short and simple that a school boy can evaluate its x without effort. A high school book on Geology and Biology ought to make it evident to any one that our complex world has evolved from a simpler form and that life forms have developed from simpler life forms. And yet some are saying here is a question you must not touch. Let it alone. It is dangerous. Do not work with this equation. We must not let the value of x get out. Wrap it up in a package, put it in an iron box and lock the door with the key of statute law. If you do not, it is such a lively proposition that the fool thing will solve itself.

Again, scientific study develops in us patience and fairness in a degree beyond that of most other subjects. Engage in a minor investigation or even read through in detail the history of great research and you will appreciate something of the patience required for such an undertaking. Madame Curie worked months in the treatment of many tons of pitchblende in order to get a few hundredths of a gram of radium. Roentgen after years of experimenting with the vacuum tube, one day so the story goes, went out in the fields to take some pictures. Upon returning to the laboratory, he placed the exposed plates in the same book with the key to his house, and went on with his experiments. The next day upon developing his plates he found upon each negative in addition to the picture which he had taken the

impression of a key. There was but one explanation. The ray which made the photograph of the key had come from the vacuum tube, penetrated the cover and leaves of the book and acted upon the sensitive plate after the manner of light waves. Further tests were conclusive. Not knowing the nature of the strange phenomenon, he named the streams of energy x-rays and the next day announced his discovery to the world. Then you say it all came by accident, and so it seems, but note that the accident was the sequel to a long series of experiments covering years of patient study and investigation.

Intimate contact with scientific investigation is bound to give the student a sense of values and develop within him the attitude of fairness. Science more than any other one influence is making for the spirit of fairness and tolerance in the world today. It is no accident that throughout our country so many deans and college presidents are being selected from the ranks of the science faculties. With such persons it is the habit to get all of the facts before acting and then to pass judgment strictly on the basis of the facts. We can not have too much of the scientific spirit and method in college administration.

One of the most fascinating things about science is that it makes for progress. It is always advancing and always new. However, the true investigator of nature works slowly and with great care. He is no destructive critic of laws as they are. When he finds false theory, he crowds it out slowly and finally banishes it altogether by introducing a new one which is based on proven and obvious fact. With no malice in his heart but with the power of truth in his argument he destroys error and so contributes to the onward march of progress. Science asks no one to change an opinion until there are very clear reasons for doing so but when a new idea does appear that really makes for progress, she demands that we push ahead.

If you are really scientific, you will be progressive, not only in one department of life but in all. Only now and then do we find a person who is progressive and up to date in one line but not in others. I know a man in another state who is a wealthy and progressive farmer. He uses modern methods in his business, reads the bulletins of the state experiment station, keeps in touch with all the experiments in agriculture and is eager for all kinds of such scientific information. He goes to the best modern authorities for his information about farming but for his interpretation of religion he goes to the writers of the Middle

Ages. He has an automobile—latest model and two or three of the best and most improved tractors to do his farm work but is satisfied with a 12th century oxcart interpretation of Christian truth. Only a freak rider can stay on a bicycle when it is not in motion and he is very nervous in the act. Every world, every star, every molecule, every atom moves. Progress is the law of life, every life.

And lastly, science helps us solve the greatest of all questions —that of God, human life, and destiny. Here you have the greatest mystery, the most difficult equation and the hardest x of all to evaluate. It is strictly in keeping with the best ideals of science when one is faced by two hypotheses the one no more clearly established than the other, to accept the one that works best in an effort to solve nature's problems. Certainly then we may carry this practice over into the field of faith. I once heard a distinguished professor of mathematics from one of our universities give a lecture in which he said one can work out a perfectly logical philosophy of life leaving God entirely out or one can work out a philosophy of life just as logical putting God in. This man has done a great many things in Mathematics and perhaps he can do as he said—construct an equation of life wherein God equals everything and another wherein God equals nothing, the one just as logical as the other. Then what one shall we accept? As we have remarked above, it is quite in keeping with the method and spirit of science to choose the one that works best, that which becomes a man struggling for better things and best enables him to realize the ideals that fill his breast.

Science wants to know; science searches for the facts and is not afraid; science is patient and fair and just; sicence believes in progress, she never takes a backward step and science demands a God that is big enough for a man. In your study of the sciences in college, whether you remember the facts or not, try to catch something of her spirit.

Teachers who become permanently disabled after 20 years' service in State secondary schools of Ecuador, or who have reached the age of 55, may retire with full pay, according to recent decree of the provisional government. In the event of disability before completion of 20 years' school service, a pension in proportion to the length of service is allowed. —*Dept. of Interior.*

SHOULD BIOLOGY BE INCLUDED IN THE TRAINING OF EVERY TEACHER? IF SO, WHAT SHOULD BE THE NATURE OF THE COURSE?[1]

By Oren E. Frazee,

State Normal School, LaCrosse, Wis.

Introduction.

The question is interpreted to mean that the training referred to is a four-year course of training in any one of the nine normal schools of Wisconsin, and that such training qualifies for the degree, Bachelor in Education. Further, that whatever the particular course may be which the student pursues, the study of biology shall be included. And finally, the nature of the course is interpreted to mean that the characteristics of such a course be given the kind of biological science, its content, the amount of time to be allotted, and the sequence of the courses.

Some Observations.

The normal schools of Wisconsin now give some biological training in most of their courses. It was not always clear from a study, which I made recently, of the catalogues of the various schools whether biology was a requirement in some of the curricula offered by a given school. It is obvious, however, that variations occur with respect to the kind and the amount of biological training required in the various courses of the nine normal schools. For example, little or no biological training is required in the primary-intermediate courses; a bit more in the grammar grade courses; but in all schools maintaining courses for the training of high school teachers, at least one-half of a year in biology is required of all whatever the major subject. From 24 to 30 hours constitute the requirement for a biology major in the three-year curricula maintained by some of the schools. Exceptions may be noted, however, in the case of a three-year course in art, and in the three-year course of domestic science, and similar courses that no biological science other than hygiene is included. Again, the courses of agriculture and of physical education include more of the biological science than the average ones maintaining the three-year courses.

Examining the matter from another point of view it may be noted that the different schools publish, and presumably offer, all they publish, a varying number of biological courses. At Eau Claire, five courses; LaCrosse, eight courses; Milwaukee, eleven courses; Oshkosh, eight courses; Platteville, twelve

[1]Delivered at Association Wisconsin Normal School Teachers (Biology Section), Madison Wis., April 5, 6, 7, 1926.

courses; River Falls, seven courses; Stevens Point, ten courses; Superior, five courses; and at Whitewater, twelve courses. Some of the above courses include physiology work.

The observations are, then, that under the present organization of the two and three year curricula, biological science is required more or less in the various normal schools. Since this is true, it follows that the requirement for biology in the different courses under four-year curricula will be, or ought to be, strengthened. To be sure, any curriculum making is always a matter of relative values and whether biology is included more than formerly will be based upon the proposition, "Is the subject-matter of biology, the methods employed by biology teachers, and the interpretations in full consonance with twentieth century educational needs and practices?" (It is a matter of chagrin to teachers of biology, I think, that the board of normal school regents have favored but two or three hours of educational biology as a requirement in the four-year curricula.)

Reasons for a Course in Educational Biology.

Some years ago, I made a study of the courses offered in biology in the normal schools of the United States. That was in 1914 and the study gave me my first realization that biology courses which were based upon the general point of view of Agassiz, "Study the fish" were not as acceptable to some of these teachers of biology as I had supposed. My work in college and university with specialists in botany and zoology had not shown me the problems of normal school teaching of biological subjects at all.

We have all seen how superintendents of schools have long been clamoring for courses in biology which would get away from the archaic plan in having the work in biology consist of so much and so insistent "viewing the dead remains" of the plants and animals around the laboratory table. The point of view of the educator, the superintendent, and all who have made a close study of the possibilities of the adaptations of biological teaching to the needs of children and students is that the science of living phenomena developed from the point of view of the experiences of the children is the only rational program. Biology, not for the sake of the rigid and formal procedures demanded by the fundamentalists in the study and development of the science, but biology for the sake of developing the ever-present experiences of the student with living phenomena. Genuine educational courses in biology are demanded as fundamental in

the training program of prospective teachers. Our trouble has been that our normal school teachers of biology have been university trained persons interested in the subject for what it offered as pure science, rather than making a study of adaptations of the subject-matter and materials to the needs of the children in the schools to whom these prospective public school teachers must go. Not until the normal schools themselves begin to train the teachers who are to teach in the normal schools, or until they have more control over the preparation of such teachers, will we reach more ideal conditions. It, of course, begins to appear that we may have a greater opportunity in this direction so soon as four-year degree courses may be given in the normal schools.

A second survey which I undertook, following the war, sought to determine whether school men, i. e., superintendents and teachers of biology were contemplating any changes in the courses of study in their schools. Both normal school and secondary school educators were included in the canvass. With respect to possible changes in biology, ninety-five per cent of those replying from all over the country gave it as their opinion that a great change was coming and had come in part in the point of view in teaching biology. It was freely indicated, too, that the biological sciences would show great growth in the next decade.

You will recall, also, that Dr. Bagley proposed the outlines of four-year curricula for the normal schools in 1917 (revised in 1923) and in each of his curricula (primary, intermediate, grammar grade, and high school) he included a course in educational biology. In the studies supervised by Dr. Bagley with reference to the normal schools of Missouri, and looking toward changes in their curricula, it was pointed out with respect to biology that in all of the normal schools of Missouri, biology was a required subject in the various curricula. We seem a bit tardy in Wisconsin in this matter. We haven't yet said definitely that educational biology is as essential in the professional equipment of teachers as psychology.

Some Special Reasons for the Course in Educational Biology.

A survey of the point of view held by teachers of psychology, pedagogy, educational measurements; by teachers of sociology, and the social sciences; by teachers of physiology-hygiene; by teachers of domestic science; and by teachers of biology them-

selves, reveals that all demand some rational course in educational biology to be prerequisite to their courses, and that it function as closely as possible. (Survey made for this meeting.)

For example, a teacher of biology in this state puts it well when he says: "There should be a first course in educational biology for the purpose of orientating the student with respect to the science of biology, its scope in general, its historical background, and a knowledge of its leading principles."

From a teacher of physiology-hygiene: "Notwithstanding the fact that physiology is the 'physics and chemistry' of living matter, it is absolutely essential for the student to come to physiology and hygiene with the biological background concerning natural processes."

From a teacher of the social sciences: "I want my students to have a course in educational biology as prerequisite to any social science course. For instance, I want them to know instinctive behavior of animals, heredity, evolution, eugenics, and the natural history of races."

From a teacher of English: "I can see how the study of biology has an especial function in the training of teachers, but I do not see how it has any more to do with the preparation of teachers, nor any less, than have the other sciences. As Dr. Frank Adyelotte says, 'There is imagination in science as well as in literature, reason in literature as well as in science, and human truth in both.' "

From a teacher of education: "It is necessary to have at least a first course in educational biology which will help us in the field of educational measurements, particularly with respect to the laws of inheritance, variations, and subjects contemporary with introduction to teaching. It must be prerequisite to educational psychology always."

From a teacher of pedagogy: "It occurs to me that the following sequence would give a most valuable basis for training the student professionally: Educational biology—4 units, physiology-hygiene—3 units, educational psychology—3 units, educational measurements—3 units, and educational sociology—3 units. Of course in this discussion, I am not stressing the work of the training school which tests the student's professional equipment afterwards."

From a teacher of cooking: "Students who come to my work should know the physical body, the food-getting work, work of cells, bacteria, yeasts, and molds."

From a teacher of applied chemistry: "My students make better progress if they come with a knowledge of physiology and hygiene, bacteriology, and a general knowledge of life-relations."

There are too many of these to quote further but there are many more including statements from critics and supervisors in the training schools which indicate that there is much to support the position that in a normal school, an organization of biological subject-matter which will function more intimately with the student's professional preparation in the normal school and which does not lose sight of the needs of the teacher in service after he leaves the normal school is fundamentally sound. Unless teachers of biology accept the challenge to prepare revised courses more in harmony with the needs, it would not be surprising to find that such work in biology as is now demanded by school people having to do with the preparation of teachers would be taken over by departments especially created to supply these requisites.

The Nature of the Course in Educational Biology.

The first course in educational biology should be given in the first year and receive four credits for one semester of eighteen weeks. (This is at variance with the report of the presidents to the board of regents recently with respect to the number of credits, they recommending two and later three credits instead of four.) In the second semester of the first year, a course in physiology-hygiene carrying three credits completes the biological science for the first year.

Brief Analysis of the First Year's Work.

In educational biology, there should be time devoted to what one may designate as introductory to the body of the course. This should include some time devoted to understanding terminology, and definitions. The aims of the course should be definitely set out. The aims of the teacher of biology and of the school, and the aims of the student must be emphasized. The professional aims, of course, would receive the most attention. Then the scope of the subject-matter in general and the scope of the course immediately at hand should be developed with care and with enthusiasm. Present day trends of the teaching of biology should be included. Attention must also be given to the general methods which are to prevail in developing the course, and a study made of some of the pioneers in the field of biology.

THE BODY OF THE COURSE IN EDUCATIONAL BIOLOGY.

1. A study of food-getting, adaptations of life, and reproduction. These fundamental processes are studied separately for each of the groups of the plant kingdom and for each group of the animal kingdom. For example, food-getting is studied with respect to one-celled forms, first, examples of both plants and animals being used and individually developed. Afterwards an examination of many celled forms is made until enough have been studied that certain principles are clearly established with respect to food-getting. Man and his problems in this connection are not overlooked but, on the contrary, emphasis is placed on the extensive program of agriculture, transportation of foods, as well as the manufacture of products to serve him, and a study of relative food values.

After food-getting the same plan is followed with respect to the development of adaptations, that is, each of the groups of plants and animals is reviewed and general principles developed, and applications to man are included at the close.

A study of reproduction follows and is organized around the various groups from the lowest unicellular forms to the highest and stress is placed upon the higher forms in order to prepare for a better reception of the study of genetics. (It will be noted that the plan is cyclic and because it is a constant view and review of the fundamental laws, makes for more lasting impressions as well as developing the method in the subject.)

2. A study of plants and animals in their life-relations—the dependencies and the interdependencies of all life upon the factors and forces of the environment. Here selections are made from the various great groups of life and the fundamental life cycles are developed; the various parasitic, saprophytic, and mutualistic relations made clear. Man's natural dependences as well as some of his social relations are introduced.

3. A study of the economic relations, together with the fundamental questions of conservation, and the improvement of plants and animals by plant and animal breeding. The attempt here is to take advantage of developments which were developed under adaptations and natural relations and use those studies in introducing the new work under economic relations. These are studied from two points of view: namely, first, the economic importance of the groups, and secondly, the economic products and their sources. The furtherance of the economic program

is developed with problems of conservation. The effort here is to establish right thinking and make applications to conservation of human life. This division closes with a consideration of plant and animal breeding which from one point of view furthers the economic program and from the other prepares for the lessons which are to come with respect to man's improvement in the next division of the work. The effort here is to secure the essential pictures with reference to the way of the wild, and the great laws of inheritance as they are known in relation to plants and animals.

4. A study of man's improvement, eugenically and euthenically. This is the last division of the course. Such an outline and point of view as that used in Walter's Genetics may be used to steer the thinking at this point. As will be observed, the course is a survey course and is in keeping with the best pedagogical principles, namely, that it is well to have students study any subject as a whole, first, and then a beginning with respect to differentiations of the subject-matter may be made.

I'll not take the time to outline the course in physiology-hygiene which I have indicated above as the course for the second semester of the freshmen year, but it too should be carefully built up. Briefly, it should embrace the following:

Introductory Work. This should consist of a survey of the historical background of physiology, together with a clear statement of the aims and objectives, scope of the subject-matter, the trend of physiology teaching, the vitalistic versus the mechanistic points of view as well as the latest teaching which involves the case method for both physiology and hygiene instruction.

The Body of the Course. A program which skillfully blends the matters of location, parts, functions and the care of the individual parts of the body. The biological background should be constantly held throughout the course. The physiology and care of the cells of the body constitute the physiology and hygiene of the body as a whole. Aspects of personal domestic, public (especially school hygiene), and social hygiene.

Briefly, the above program appeals to me as one which will give enough work to satisfy the teachers in the social sciences, educational psychology, and other subjects which are scheduled to come the following years in the four-year curricula.

With respect now to the other courses which should constitute a major, I wish to point out that the student in the various normal schools will be obliged to select for his specialty. Some schools

will no doubt emphasize the zoological and others the botanical lines. If his field is to be in the high schools maintaining biology courses, he will need to follow his first year with one year of zoology, with one year of botany, with one-half year of bacteriology, with one-half year of genetics, evolution, and eugenics, and finally as a major requirement he should have one-half year in the teaching of the biological sciences.

If the student is to be a teacher of agriculture, he will need a different arrangement of the biological sciences, or if a teacher of physical education he will need a somewhat different arrangement. Of course the latter cases refer to biology minors and three to four courses will usually satisfy in this.

DYESTUFFS USED TO MAKE BETTER RUBBER.

Dyes and other organic compounds are now being used for prolonging the life of rubber as well as for speeding up the vulcanizing process in making the finished product from the sticky crude plantation rubber. Donald H. Powers of Pennsgrove, N. J., described how the dyestuffs industry is thus helping the rubber manufacturer, at the meeting of the American Chemical Society at Philadelphia.

"Organic compounds have been used as accelerators in vulcanizing rubber for the past ten years," Mr. Powers said, "but the dye industry is now furnishing some of the most widely used ones as well as developing newer and better ones. In addition, an organic anti-oxidant, a substance that slows up the aging of rubber, has been developed."

The world rubber situation will be profoundly affected when the secret of keeping rubber "alive" is solved. Rubber deteriorates fast on exposure to sunlight and under nearly all conditions to a varying extent. Chemists have been trying for years to find some substance with which to "dope" the rubber and keep it from aging too fast. A new substance put on the market by the dyestuffs industry, Mr. Powers said, is already prolonging the life of rubber many fold.

Before the use of organic dyestuffs in rubber products only a few inorganic colors were available, Mr. Powers said. But now a wide variety of shades is used producing stocks of superior products, and the dyestuffs industry is busy searching for new and still better compounds for use in rubber manufacturing.—*Science Service.*

LIGHT ALLOYS MAY BE METALS OF FUTURE.

America leads the world in the practical development of light tough alloys for structural purposes, Francis C. Frary of New Kensington, Pa., told the American Chemical Society. There are only two light metals, aluminum and magnesium, which seem to face an increasing demand in the future, Mr. Frary said. Other light metals are chiefly used as chemical reagents, but not for alloys.

Magnesium-rich alloys are being perfected and their use in aviation and other fields where lightness is the main consideration and cost relatively unimportant, is increasing. Aluminum alloys on the other hand are competing with brass and steel, especially in the transportation field. Sheet, castings, forgings, and structural shapes made of these alloys, have the strength of mild steel and only one-third its weight, Mr. Frary said, and their use will rapidly increase.—*Science Service.*

THE CONSTRUCTION OF A TEST TO MEASURE MATHEMATICAL ABILITY.

By Charles A. Stone,
University High School, University of Chicago.

Recently the writer had occasion to compare the mathematical ability of Junior High School pupils and Senior High School pupils. After searching the field for tests to make the comparison it became apparent that the most of them measured the ability to retain subject matter. Though it was desirable to measure the above ability, it was deemed necessary to measure the mathematical ability to solve problems that occur in new and practical situations. Several of the tests tried to measure general mathematical ability but not of the type desired by the writer. It might be mentioned that by the term "mathematical ability" is meant that composite of specific abilities that are necessary for success in a wide range of mathematical studies starting with arithmetic, algebra, and intuitive geometry, and continuing through deductive geometry and the subsequent courses in mathematics, including applications of mathematics to practical situations.

One of the tests that attempts to measure mathematical ability is the Rogers Prognostic Test of Mathematical Ability. Instead of trying to find out whether the pupil could do certain essential things in algebra or in geometry, this test attempted to solve a more difficult problem, which is that of enabling the teacher to know in advance the innate mathematical ability of the pupil, that is the inborn power of the pupil along mathematical lines.

A test such as the above can be of great service in the solution of three pressing school problems. The first is that of advising the pupils at the end of the ninth school year concerning their further studies in mathematics. The second problem arising in every school is that of knowing whether or not a pupil's previous school marks in mathematics can be depended upon, and especially is this a vital question when there seems to have been a difference of opinion among teachers as to the pupil's ability. The third problem which teachers are now beginning fully to realize is the necessity of adapting instruction in mathematics to the capacities of pupils, since careful investigations have shown that great individual differences in mathematical skill and insight exist among pupils.

The Rogers Test was deliberately planned to determine the

mathematical intelligence of pupils whose training in mathematics has included about five months of algebra and five months of intuitive geometry, and it was assumed that the test would be given at the end of the ninth school year. The tests, however, can be given at the end of the eighth and the tenth years but no standards have been worked out for these years. It can be easily seen that while the above test measures a specific ability in mathematics, it is not suitable for measuring effective mathematical ability acquired through training in mathematics.

Another test of mathematical ability is the Thurstone Vocational Guidance Test which was issued in 1922. It was prepared by Dr. L. L. Thurstone, of the Carnegie Institute of Technology. It consists of five separate tests, one in each of the following subjects: arithmetic, algebra, geometry, physics, and technical information. While the test is one of mathematical ability its scope is rather narrow being designed to enable the prospective engineering student to obtain in advance a rough measure of his own ability to succeed in engineering courses of the freshman year of a technical school.

H. N. Irwin also designed a mathematical ability test. His test, however, deals with but one trait or field of geometric ability —that of space perception or visual imagery. While this is an important phase of mathematical ability, the test is too specialized to measure the power of a pupil in the subject.

It was thus evident to the writer that a suitable test for measuring effective mathematical ability, that is the ability to use one's knowledge in useful or practical situations after having been through the required mathematics, was not in existence. It was therefore necessary to construct a test if it was to be learned whether the mathematics taught was really developing this power.

A preliminary practical test involving some of the important principles of geometry and algebra was devised, and was given to a class of 55 pupils that had had approximately one year of algebra and the required geometry involved. This preliminary testing should be the first step in the preparation of a test. By means of such a test it is possible to use the type of problem or question later to be employed for the purpose of determining whether or not certain questions or problems are mis-fires, that is, questions which fail of the purpose to measure adequately. This may be due to faulty wording, to testing on too technical points, or on points not brought out in the particular class where the pupil is located. The test given was as follows:

1. (a) Why are the lines drawn by the T-square parallel. (Fig. 1.)
(b) How would you draw a perpendicular to these lines using the T-square. (Fig. 1.)

2. In order to put in a brace joining two converging beams and making equal angles with them, a carpenter places two steel squares as here shown so that OP = OQ. Show that the line PQ makes equal angles with the two beams. (Fig. 2.)

3. If we place a draftsman's triangle against a ruler and draw AC, and move the triangle along as shown and draw A′C′, is AC = A′C′. Why? (Fig. 3.)

4. Figure ABCD is a parallel ruler jointed at A, B, D, and C. Why does AB always remain parallel to CD? (Fig. 4.)

5. A sailor wishes to measure the distance from B to D across a stream as shown in the figure. Find the number of degrees in angle D. What line would the sailor measure giving him the distance from B to D? (Fig. 5.)

6. Two timbers are jointed so that BD makes equal angles with the edges of the timbers. EB meets BC so that x = 50 degrees. How large is angle Z? (Fig. 6.)

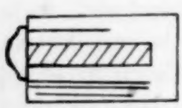

FIG. 1

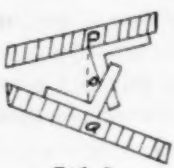

FIG. 2

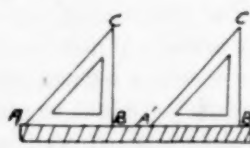

FIG 3

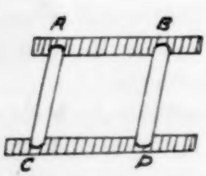

FIG. 4

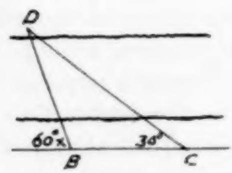

FIG. 5

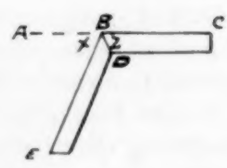

FIG 6

7. To find the distance between P and Q, two points on opposite sides of a stream, the measurements were made as indicated. Find PQ. (Fig. 7.)

8. Wishing to measure the distance AX across a ravine, a boy placed a pair of compasses QCP at the top of a post AQ so that arm CP pointed to X. He then turned the compasses around, keeping the angle made by the compasses fixed, and sighted along the arm Y. He then felt satisfied that he could determine the distance AX across the ravine. Was he right? Why? (Fig. 8.)

9. In the balance scale of the figure CO = OD. Show that the scale pans C and D are always the same distance from the middle post AB. (Fig. 9.)

10. A circular pool is 20 feet in diameter and is surrounded by a walk 4 ft. wide. Find the area of the walk.

11. How many square inches of paper will be needed for the kite at the left? (Fig. 10.)

12. Find the area of the flat figure as shown. (Fig. 11.)

13. A ladder AB shown in the figure stands upright against the wall. If the top of the ladder is allowed to slip down a distance four ft. to point C, the bottom B slides to point D, 8 ft. from the foot of the wall. Find the length of the ladder. (Fig. 12.)

14. Mr. Brown paid one third of the cost of a building. Mr. Johnson

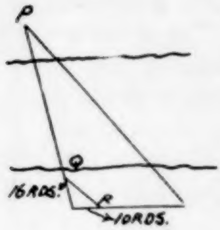

FIG. 7

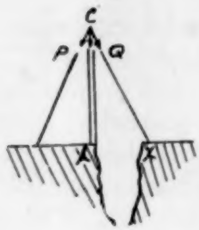

FIG. 8

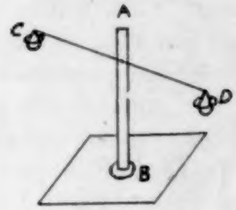

FIG. 9

FIG. 10

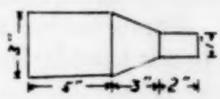

FIG. 11

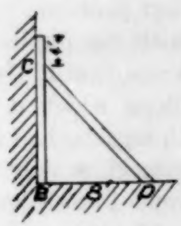

FIG. 12

received $5,000 more annual rent than Mr. Brown. How much did each receive?

15. In the adjoined figure find the length of the brace AB and the distance from B to C. (Fig. 13.)

16. In the roof ABCEF shown in the figure, find the length of the parts whose dimensions are not given. (Note that triangle EBC is isosceles, and that triangle ABD is equilateral. (Fig. 14.)

17. The bases of a trapezoid inscribed in a circle are 8 inches and 12 inches respectively and the altitude is 3 in. Find the distance from the center of the circle to the lower base. Also find the radius of the circle. (Fig. 15.)

18. A table O is pushed into the corner of a room as shown in the figure. A point P on the edge of the table is 8 inches from wall AB and 9 inches from wall BC. Find the diameter of the table. (Fig. 16.)

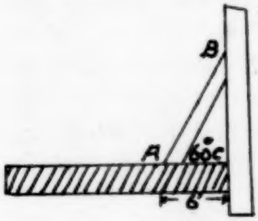

FIG. 13

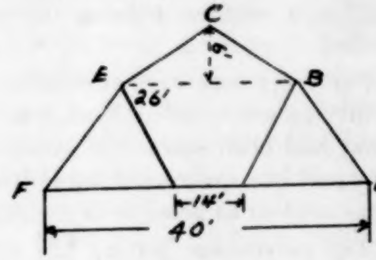

FIG. 14

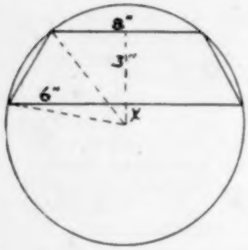

FIG. 15

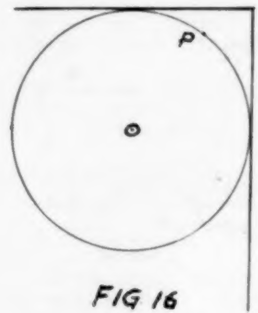

FIG 16

Twenty-one per cent of the class gave correct replies for the first problem. An examination of the papers and consultation with the pupils revealed the fact that a great number did not know that a T-square is perpendicular to the edge of the board along which it moves. Pupils taking mechanical drawing or those who had courses in mechanical drawing seemed to give a correct answer to this problem. Since this question involved some knowledge, foreign to the mathematics, it was ruled out.

The second problem was worked by 30% of the pupils. It was found that the majority of the students did not understand what angles were wanted. Thus the reading of the problem was changed and the angles that were to be proved equal were definitely named.

Sixty-six and two-thirds per cent of the class gave satisfactory answers to the third problem. Some failed to see that the corresponding or exterior-interior angles were equal.

Fifty per cent were able to do the fourth problem. Consultation with a number of the pupils failing to work this problem correctly revealed that they had not mastered the principles taught concerning the parallelogram. They failed to see that the opposite sides of this figure were always equal regardless of the position taken. This problem was not included in the final test as a problem relating to parallel lines was already included.

Forty per cent were successful in the fifth problem. Lack of ability to work the problem was due to inability to connect up what had been learned in geometry with a practical situation. The problem was re-worded for the purpose of making the conditions as clear as possible to the student.

The percentage getting the sixth problem correct was only thirty-three and a third. Some pupils thought that the diagram

represented a dihedral angle while others did not know the meaning of the word "joint." Thus the wording was changed and the figure was re-drawn making line "BD" a little larger. The figure thus drawn makes a better impression upon the student.

The seventh problem was relatively simple, being worked by 72% of the class. Those who could not work it did not know that QR was parallel to PC. This was stated in the problem in the final test.

The eighth problem was also simple being worked by 79% of the pupils. The problem was re-worded as shown in the final form, so that the questions might be more direct.

The ninth problem was worked by but 30% of the class. They could not see the congruent triangles. This problem was omitted from the test as problem eight dealt with congruent triangles.

The tenth problem is a problem that does not require a knowledge of secondary mathematics. The ordinary sixth or seventh grade pupil should be able to do it. It was included for the purpose of determining how well the pupil can connect his elementary mathematics with a practical situation. The problem also involves reasoning ability. The eleventh problem was included for the same reasons. Twenty-five per cent were successful in the first of the two and 45% in the latter. The low percentages upon investigation were found to be due not to the difficulties of the problem but to the fact that the pupils could not react in a practical situation. The twelfth problem was confusing. Some thought the figure was that of a nozzle and others were confused by the numerous dimension lines. The problem was therefore omitted. Only 20% were able to get this one right. The thirteenth problem proved to be one of great difficulty. Only 10% of the class were able to do this problem. The problem was included, however, as one of the aims in constructing this test was to so construct it that no pupil could get a score of zero and such that no pupil would get a perfect score.

Sixty-six and two-thirds percent worked the fourteenth problem correctly. This problem is not particularly difficult being purely a reasoning problem requiring a little thinking. Arithmetic or algebra can be used in solving it.

The fifteenth problem was solved by 50% of the class. This was not particularly difficult. Some pupils did not make a part of their knowledge, the fact that in a 30°-60° right triangle the short side is one-half the hypotenuse.

In the sixteenth problem the difficulty again arose of applying mathematical knowledge to a practical situation. 14% of the class were able to effect a solution of this problem.

The seventeenth and eighteenth problems proved to be extremely difficult, and as two difficult problems had already been included for final testing, it was decided to omit these.

In constructing a test the maker may arrange the questions in the order of difficulty, and thus penalize the bright pupil who penetrates to the end where the difficult questions are grouped. He may place the more difficult questions first, and penalize the dull pupil who must surmount this initial barrier. He may arrange the questions without any reference to order of difficulty, thus tempting pulpils to skip around and waste their time in selecting what seams to be the easy problems. The fourth method is the arrangements of questions in cycle, the questions within each cycle increasing in order of difficulty. The cycle form has the following advantages:

1. Encouragement is offered to all pupils when they find something easy in which to begin.
2. The poor pupil is not penalized until he approaches the end of the first cycle.
3. The good pupil is checked as he approaches the first point of difficulty but he increases his speed after passing this point.

At first it was thought that the best arrangement of problems would be that of relative difficulty as determined in the preliminary testing described above. This idea was abandoned in favor of the cycle plan, that is, of having every fourth or fifth problem a relatively simple one, or of having easy and difficult problems follow one another. This arrangement would tend to encourage the pupil to proceed forward in the test, whereas in the former arrangement when he came to a problem that he could not solve the tendency would be toward discouragement if the pupil discovered that as he progressed the difficulties increased. Thus the order of the problems as shown in the test appended is not that of relative difficulty as simple problems are scattered throughout the test.

The mimeographed forms of the modified test were then passed out to several pupils of average ability who took the test for the purpose of determining the length of time to be given to the test. It was found that 45 minutes would be sufficient for the completion of the test. This was the time limit allowed in administering the test to the schools participating in the study

carried on by the writer. The test as used for experimentaton follows.

The writer is aware of the fact that the test can be greatly improved. He feels, however, that the attempt to construct such a test will be justified if similar tests of a better quality are constructed as a result of his efforts.

A Test of Mathematical Ability.

1. Wishing to measure the distance AX across a ravine, a boy placed a pair of compasses QCP at the top of a post AQ so that the arm CP pointed to X. He then turned the compasses around, keeping the angle made by the compasses fixed, and sighted along the arm to Y. What line would he measure to get the distance AX? Why? (Fig. 8.)
Answer.

2. Two timbers are jointed as shown so that the line BD where they join makes equal angles with the edges of the timbers. EB meets BC so that LX = 50°. How large is angle Z? (Fig. 6.)
Answer.

3. A sailor wishes to measure the distance from B to D across a stream as shown in the adjacent drawing. Not being able to measure BD directly, what other line might the sailor measure that would be equal to the line BD. *Suggestion:* Find the number of degrees in the angle D. (Fig. 5.)
Answer.

4. To find the distance between P and Q, two points on opposite banks of a stream, the measurements were made as indicated in the figure at the left. QR is parallel to PC. Find PQ. (Fig. 7.)
Answer.

5. If we place a draftsman's triangle ABC against a ruler and draw AC, and move the triangle along to position A'B'C' as shown and draw A'C', why is AC parallel to A'C'? (Fig. 3.)
Answer.

6. In order to put in a brace PQ joining two converging beams and making equal angles with them, a carpenter places two try squares as here shown so that OP = OQ. Show that the line PQ makes equal angles with the two beams, i. e., $\angle QPR = \angle PQS$. (Fig. 2.)
Answer.

7. A circular pool is 20 feet in diameter and is surrounded by a walk 4 feet wide. Find the area of the walk.
Answer.

8. How many square inches of paper not allowing for waste will be needed for the kite as shown. (Fig. 10.)
Answer.

9. Mr. Brown and Mr. Johnson purchased a building. Mr. Brown paid one third of the cost of a building; Mr. Johnson received $5000 more annual rent than Mr. Brown. How much did each receive?
Answer.

10. A ladder AB shown in the figure stands upright against a wall. If the top of the ladder is allowed to slip down a distance 4 ft. to point C, the bottom B slides to point D, 8 ft. from the foot of the wall. Find the length of the ladder. (Fig. 12.)
Answer.

11. In the adjoined figure find the length of the brace AB and the distance from B to C. (Fig. 13.)
Answer.

12. In the roof ABCEF shown in the figure, find the lengths of the parts whose dimensions are not given. (Note that $\triangle EBC$ is isosceles, and that $\triangle ABD$ is equilateral.) (Fig. 14.)
Answer.

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BEST FOOD DYES MADE IN AMERICA.

How American chemists had to get busy to maintain the pretty pre-war colors of domestic candies and cake icings with home made dyes during the World War and afterwards, was described at the recent meeting of the American Chemical Society at Philadelphia by W. C. Bainbridge of Brooklyn, N. Y. From 1907 to 1914 food colors were purified from imported crude dyes from Germany but after that time American manufacturers had to produce their own from domestic raw materials, Mr. Bainbridge said.

"The use of coloring matter in foodstuffs is an old established practice which originated in the workshop of Nature," Mr. Bainbridge explained. "Man in his endeavor to meet the culinary requirements of advancing civilization found it necessary to perpetuate the familiar and characteristic hues that suffered deterioration in the process of cooking or preserving. Thus the art of tinting foodstuffs was established.

"At first the juices of such vegetables or fruits that lent themselves readily to extraction and concentration were employed," Mr. Bainbridge said, "Those coloring matters were as a rule easily destroyed and the results were not satisfactory. But the advent of coal tar colors brought the desired permanent shades and hues and these soon found wide use. In 1907 the U. S. Government passed a law making the use of certain of the harmless coal tar colors in food permissible and barring the rest."

The war established a new industry in the United States and a larger variety of truly superior dyes are now being produced here as a result, it is said.—*Science Service.*

PREPARATION FOR RECITATION REQUIRES NEARLY AN HOUR.

To determine the time actually required by high-school students for preparation of their lessons outside the recitation period, a questionnaire was sent to students by the Commission of Secondary Schools of California. Replies were received from 95,000 students. Of these, 4.2 per cent frankly admitted spending no outside time in preparation; 9.6 per cent reported spending from 1 to 15 minutes for a single recitation; 31.6 per cent, 16 to 30 minutes; 44.5 per cent, 31 to 60 minutes; and 10.1 per cent claimed to devote an hour to outside study for each recitation. From these replies the inference was deduced that an average of from 45 to 60 minutes would be required for thorough preparation of a high-school recitation.—*Dept. of Interior.*

THE HIGH SCHOOL CHEMISTRY CLUB.

By Harold Walker,*
Rapid City, S. D.

In the spring of 1925 the writer was asked to prepare a paper on the High School Chemistry Club for the Chemistry and Physics Round Table at the meeting of the State Teachers' Association last fall. At the University of Chicago during the summer he could find little written in regard to science clubs. Therefore he decided to carry out a thorough investigation of science club work. For that purpose a questionnaire was planned with suggestions from Mr. Pieper of the University of Chicago High School and Dr. Downing of the School of Education. The writer is also greatly indebted to Mr. Pieper for his valuable criticisms and suggestions for preparing this paper. The questionnaire was sent out to 156 high schools, practically all of them with an enrollment ranging upward of eight hundred. One hundred twelve replies were received.

In the 112 schools reporting only twenty-three have an active chemistry club. Forty-nine have no active science club of any kind. Forty have either a joint science club or a club in some particular science other than chemistry. Of these forty clubs seven are radio clubs only. Twenty-one chemistry and other science clubs have been discontinued. Five schools reported that they expected to organize either a chemistry club or other science club.

For twenty of the twenty-one discontinued clubs the reasons given for discontinuance in the order of the number of times mentioned are the following.

(1)	Too many other organizations or activities	5
(2)	Lack of interest	5
(3)	Lack of time on the part of the teacher, or teacher too heavily loaded	3
(4)	Died a natural death	2
(5)	Too many clubs with social purposes only	2
(6)	Change of faculty	2
(7)	Not enough students	1
(8)	Could not get pupils to attend	1
(9)	Teachers tired of doing nearly all the work	1
(10)	Lack of cooperation among teachers	1
(11)	Club became too largely social in nature	1

Of the chemistry clubs, two had just been organized, three had been running for one year, four for two years, four for three years, five for four years, and four for a longer period of time. Of the other science clubs three had been running for one year, one for two years, six for three years, six for five years, three for

*Since deceased.

six years, and eight for a longer period of time. No chemistry club reporting had been running longer than twelve years and no other science club longer than fifteen years,

In the questionnaire the following five purposes for a science club were listed:

A. To stimulate interest in science.

B. To provide extra activity for those pupils who are especially capable.

C. To discuss things for which there isn't time during the regular periods.

D. To promote better understanding between pupils and teacher by informal contact in these meetings.

E. To arouse community interest in science.

Following is a record of the number of times each was checked by chemistry teachers:

	First	Second	Third	Fourth	Fifth
A	17	3	1	0	0
B	6	6	7	4	0
C	2	5	7	0	3
D	0	5	3	6	2
E	0	3	4	2	6

Following is a record of the number of times each was checked by other science teachers:

	First	Second	Third	Fourth	Fifth
A	19	11	2	1	0
B	9	11	7	1	0
C	4	7	9	6	3
D	2	3	6	5	4
E	2	2	5	5	9

Many other purposes were listed. The study of chemistry as applied to industrial and professional work was listed by six chemistry teachers. Vocational guidance was mentioned by three chemistry teachers. Social training was mentioned by five teachers of other sciences. Others purposes mentioned are the following: (1) To talk science informally, (2) To encourage home projects of a scientific nature, (3) To prepare science programs for general assembly once a year, (4) Trips, (5) To get big men for talks, (6) To put department on the map, (7) To promote higher scholarship, (8) Useful information gained, (9) To get broader knowledge of science than offered by courses, (10) To acquaint students with scientific environment, (11) To give greater opportunity for self expression than in crowded classes, (12) To keep third year student interested in fourth year and carry interest to college, (13) To give social privileges to a few not otherwise reached, (14) To give pupil

ability to present science interestingly to a non-technical audience, (15) To boss job of own in order to understand a teacher's difficulties.

Of twenty-seven chemistry clubs all but four have or did have a constitution. Of thirty-three other science clubs answering the question all but one have a constitution. Without exception all the chemistry, and the other science clubs as well, reported the regular officers which are president, vice president, secretary, treasurer or the latter two combined into one. Other officers mentioned a number of times by other science clubs than chemistry clubs are a sergeant of arms by six, a program committee or chairman of such a committee by seven, and a faculty advisor by four. (Evidently nearly all the teachers must have regarded a faculty advisor as an ex-officio officer and therefore did not mention him, as a faculty advisor is certainly a necessity.) Other officers mentioned are an editor, librarian, director of initiation, judge, parliamentarian, critic, reporter, and a member of the student council.

Of twenty-four chemistry clubs seventeen elect their officers semi-annually and seven annually. Of thirty-one other science clubs twenty-three elect officers semi-annually and eight annually.

Of twenty-six chemistry clubs fourteen reported that the club is open to all interested who are either enrolled in chemistry or have been enrolled in chemistry as against twelve with various scholarship requirements. But as the requirements are different in each case they are not reported.

Of thirty-five other science clubs twenty-one reported that the club was open to all interested science students. However three of these clubs reported a limited membership. Fourteen reported scholarship qualifications but the qualifications are different in each case.

In regard to dues twelve chemistry clubs reported none, two assessed dues as needed, two had dues of twenty-five cents, four fifty cents, two one dollar, and five different amounts.

Of the other science clubs nine reported no dues, three twenty-five cents, ten fifty cents, five one dollar, and five various amounts.

Of twenty-three chemistry clubs all but one meet in some room of the high school building. In the case of thirty-three other science clubs there was also just one club that didn't meet in the high school building.

Following are listed the various uses of dues and the number of times mentioned:

		By chemistry teachers	By other science teachers
(1)	Socials, picnics, parties, refreshments and entertainments	7	10
(2)	Equipment, supplies, books, etc	3	6
(3)	Picture in annual	2	2
(4)	Speakers	2	2
(5)	Various expenses	1	3
(6)	Movie films	0	3
(7)	Annual banquet	0	2
(8)	Demonstrations and experiments	1	2
(9)	Prizes	0	3
(10)	Trips	0	1

The frequency of meetings is shown by the following table:

		Chemistry Clubs	Other Science Clubs
(1)	Weekly	9	7
(2)	Every two weeks	6	17
(3)	Every three weeks	1	1
(4)	Monthly	7	8
(5)	Ten times a year	2	0
(6)	Twice a quarter	1	0

The report upon the hour of meeting follows:

		Chemistry Clubs	Other Science Clubs
(1)	Close of school	14	18
(2)	Evening	5	8
(3)	During school day	6	7
(4)	Noon	1	1

The best time for meeting was answered in the following manner:

		Chemistry Clubs	Other Science Clubs
(1)	Close of school	13	12
(2)	Evening	4	8
(3)	During the school day	5	8
(4)	Morning	1	1
(5)	Noon	1	0

Following is the report upon the best length of time for meeting:

		Chemistry Clubs	Other Science Clubs
(1)	¾ hour	5	7
(2)	One hour	9	19
(3)	1½ hours	3	4
(4)	Two hours	3	1

In the questionnaire the three following methods were listed for planning programs:

A. Planned almost entirely by the pupils, teacher simply approving the program.
B. Planned jointly by the pupils and teacher.
C. Planned almost entirely by the teacher.

The vote follows:

	Chemistry Clubs	Other Science Clubs
A	7	14
B	17	17
C	0	0
A and B combined	1	2
B and C combined	1	1

In the questionnaire the following program activities for a science club were listed:

A. Demonstration experiments by a pupil.
B. Demonstration experiments by the teacher.
C. Lecture or paper prepared by a pupil.
D. Lecture or paper prepared by the teacher.
E. Trips to some plant or industry or field trips.
F. Talks by outside speakers.
G. Exhibitions planned and arranged by the club.
H. Plays planned and arranged by the club.

Following is a record of the manner in which these activities were checked by chemistry teachers:

	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
A	11	3	2	0	1	0	1	0
B	0	2	2	1	2	0	3	0
C	5	7	3	1	1	0	0	0
D	0	1	3	0	0	3	0	3
E	8	1	6	4	0	0	0	0
F	5	8	4	2	1	0	0	0
G	2	2	5	1	0	1	1	0
H	0	1	2	1	1	2	0	1

The next record shows how these activities were checked by other science teachers:

	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
A	10	10	3	2	0	1	0	0
B	1	1	4	4	4	3	1	0
C	8	10	5	2	1	1	0	1
D	1	1	1	6	3	2	3	2
E	8	4	4	1	2	1	2	0
F	3	6	9	1	2	0	1	0
G	0	0	4	4	2	1	1	0
H	0	0	0	4	2	3	2	1

The most significant thing in program making is that the teacher is put in the background. This is worthy of note in planning a successful club.

A great many other activities were mentioned one or two times by either chemistry or other science teachers. Following is a list of those mentioned: (1) Annual picnic, (2) Scientific films, pictures, or exhibits, (3) To make useful apparatus for the teacher, (4) Semi-annual social, (5) Projects, problem work, research, (6) Chapel or assembly programs, (7) Annual banquet, (8) To conduct essay contest on scientific subjects, (9) Experiments only (in case of one club), (10) Current events, (11)

Annual faculty program, (12) Annual visit to some university, (13) Advertising A. C. S. books, (14) Publishing a paper, (15) Initiation ceremony, (16) To work out club designs, insignia, yells, etc., (17) Social activities, (18) Offer sophomore membership for passing best examination in science, (19) To study nature, (20) To study other sciences related to chemistry.

All of the chemistry clubs make use of outside speakers and all the other science clubs but three do the same. An inquiry was made in the questionnaire as to how many times outside speakers gave talks during the year. The same inquiry was made as to how many times a year the teacher gave a lecture or demonstration. Following is the report:

	Chemistry Clubs		Other Science Clubs	
	Outside Speakers	Teachers	Outside Speakers	Teachers
None	......	7	3	8
Seldom	......	2	......	4
One	3	3	5	4
Two	6	6	4	5
Three	3	4	6	1
Four	2	0	4	1
Five	1	0	4	3
More than five	8	0	2	2

Here again is indicated that it is better for the teacher to remain in the background as far as programs are concerned.

Of twenty-four chemistry teachers all but two have accounts of programs published in the school paper. Of thirty-four other science teachers answering the question all but one report the publishing of accounts of programs in the school paper. However the best papers submitted at club meetings are seldom published in the school paper. Only three of the chemistry clubs reported the publishing, at least occasionally, of the best papers submitted at club meetings and only five of the other science clubs reported doing this.

Of twenty-two chemistry teachers fourteen do not use the local newspaper at all. Eight others use it, at least occasionally, for accounts of programs, notices, or announcements. Of twenty-nine other science teachers eighteen report using the local newspaper.

In his questionnaire the writer asked for the total enrollment in chemistry, if a chemistry club, or, in science, if a science club. The average number of pupils attending each club was also asked and the per cent of attendance that the teacher regarded as necessary for a successful club. These figures are all so varying that the writer will only endeavor to set forth his own conclu-

sions from the mass of figures given. In the great majority of cases the club attendance indicated is small when compared with the enrollment. The average attendance for twenty-five chemistry clubs was twenty-six and the average attendance for twenty-eight other science clubs was thirty-three. The per cent of attendance that teachers regarded as necessary for a successful club varied greatly.

The mass of figures, however, have led the writer to some definite conclusions that he believes to be sound. The statements of the preceding paragraph ought not at all to be interpreted as indicating that science clubs are not successful. As already shown previously in a great many cases the club membership is limited. Many of the teachers reported that they didn't care foı a large club and in answering the question as to the per cent of attendance for a successful club some reported they couldn't see any relation and others gave such reports as: doesn't matter, any interested group, only interested ones, fifteen and on up as making a good club. The writer believes that the best measure of a club is the interest displayed and the results and that fifteen, perhaps even eight or ten, really interested people would make a good club that is worth while.

A list of problems that arise in conducting a science club, indicated in the order of the number of times mentioned, is as follows:

		By Chemistry Teachers	By Other Science Teachers
(1)	Too many outside activities, clubs, or organizations	5	6
(2)	Interesting, well planned programs	2	5
(3)	Convenient time for all to meet or lack of time for meetings	4	3
(4)	To maintain interest and attendance and yet impart information	4	2
(5)	To develop pupil responsibility, to get them to do the work and hold them to business	4	1
(6)	Development of leadership and initiative in the officers of the club	3	1
(7)	Thorough preparation on part of the pupils	1	1
(8)	To keep membership down or selection of members	1	1
(9)	Students employed after school hours	1	1

Other problems mentioned once or twice are the following:

(10) To get worth while results without extra burden to the teacher.
(11) No specific aim.
(12) Lack of faculty cooperation.
(13) To keep club from becoming a debating society.
(14) Pupils prefer other things.
(15) Something for everybody to do.
(16) Find new and original things to do.

(17) Lack of time on part of teacher.
(18) Pupils want to be entertained.

Following is a list of means for maintaining interest in the club and the number of times mentioned:

		By Chemistry Teachers	By Other Science Teachers
(1)	Interesting, well planned programs	7	11
(2)	Let pupils feel it is their own club, pupil management, pupil activity	3	10
(3)	Enthusiastic, capable teacher	5	3
(4)	Good trips	5	3
(5)	Outside speakers	4	2
(6)	Demonstrations	3	1
(7)	Scholarship requirements	0	4
(8)	Science movies	0	3
(9)	Limitation of membership	1	2
(10)	Social time, games, refreshments	1	2

Other means for maintaining interest in the club which were mentioned one or two times are the following: (11) Initiation service, (12) Discussion, (13) Congenial group, (14) Current events, (15) Something new and original, (16) Something for everybody to do, (17) Exhibit or show, (18) Plan meetings well ahead, (19) Teacher remain inconspicuous, (20) Publish a paper, (21) Club yells, songs, emblem, etc., (22) Chapel or assembly programs, (23) Annual banquet, (24) Annual outing or picnic, (25) Annual or semi-annual dance, (26) Question box, (27) School credit, (28) Not mere entertainment, (29) Contagious enthusiasm, (30) Dropped if absent so many times without excuse.

To the question: "If you regard the activities of such a club as of real value do you not think it would be better to carry out these activities in connection with class work so as to benefit the entire class?" There were forty-two replies.

Of the forty-two teachers answering this question only seven answered it in an affirmative manner, and thirty-five negatively. Practically all are in favor of any properly conducted, supervised club. Its purposes, value, and results have already been indicated. Practically all agree that there is a place for a good club because teachers are pressed for time to do the amount of regular class and laboratory work in the usual course of chemistry.

IODINE FROM SEAWEED MAKES EXCELLENT MEDICINE.

The iodine that is found in certain marine plants is 200 times as effective as inorganic iodines in its power to bring the thyroid gland back to normal. Dr. J. W. Turrentine of the U. S. Bureau of Soils, who told of his researches at the recent meeting of the American Chemical Society at Philadelphia, said that small doses of iodine-bearing substances coming from seaweed cured simple goiter. The symptons of iodism that often result from using inorganic iodides were lacking and there were no disturbances such as result from taking thyroid gland preparations.

It appears that the iodine is present in a colloidal form in the marine plants and is absorbed very slowly by the digestive tract. This lessens the chance of over-dosing, Dr. Turrentine said. He believes that the use of iodine in this form in the treatment of thyroid disturbances should be generally tried by physicians.—*Science Service.*

WHAT DAY IS IT?[1]

By R. L. Humiston,
Utica, N. Y.

I would renumber the days of the week (p. 825, from bottom, line 15 and the 6 lines following). Beginning with Sunday I would renumber them: 1, 2, 3, 4, 5, 6, 0.

This is the ordinary current numbering of the days of the week, and is the one used by astronomers. Uniformity would be gained thereby.

The change in day numbering would necessitate changing the month characteristics (p. 826, from top, line 5 and the 3 lines following). For the purpose of memorizing the characteristics, the months with their changed characteristics can be grouped as follows:

1	2	3	4
January	May	August	February
October			March
			November

5	6	0
June	September	April
	December	July

The order of a month group corresponds to the characteristic of the months in that group. Thus: January and October being first in order get characteristic 1; May being second in order gets characteristic 2; etc.

To the rule for obtaining the year characteristic (p. 827, from top, line 21 and the 4 lines following) I would add the following:

Where the last two digits are exactly divisible by 4, the year is leap and the characteristic diminished by 1[2] for January and February with the following exception: where the last two digits are two ciphers as in century years, the year is leap and the characteristic diminished by 1 for January and February, only if the century number proper is exactly divisible by 4.

We can lessen the mental computation of the year characteristics if, instead of using the characteristic rule, we use the following method:

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[1]Suggested improvements in an article bearing the above title and published in this Magazine December, 1923; pp. 825-830.

[2]If the year characteristic to be diminished by 1 is 0, then the 1 is subtracted from the next significant figure used in combination. This procedure is used to lessen computation. Ordinarily in this case, we would use the following rule:

If in this method the subtrahend is greater than the minuend, the numbers are subtracted in reverse order, and the remainder subtracted from 7 to obtain the proper result.

However, if in using the above procedure instead of the rule, the final result for the date is 0—1, then we are forced to use the rule with the final results, whereby 0—1 will give 0—1 = 7—(1—0) or 6.

In using the device of subtracting 28, 56 and 84 from the original year numbers to obtain smaller year numbers (original article, p. 827, from bottom, line 10 and the 30 lines following), the original year numbers are reduced to numbers 00 to 27 inclusive. In finding the characteristics of these year numbers the procedure is as follows:

For years 00 to 03 inclusive the year number is taken as the characteristic, the year number and the characteristic being the same; for years 04 to 07 inclusive 6 is subtracted from the year numbers, or 1 is added to 04 and 05, and 6 is subtracted from 06 and 07; for years 08 to 11 inclusive, 5 is subtracted from the year number; for years 12 to 15 inclusive the left hand digit is subtracted from the right hand digit; for years 16 to 19 inclusive the right hand digit is taken alone and 7 subtracted from it, or in case of 16 the right hand digit is taken as the characteristic; for years 20 to 23 inclusive the right hand digit is taken alone and 4 added to it; for years 24 to 27 inclusive the left hand digit is subtracted from the right hand digit. This method of obtaining the year characteristics is very easily memorized and as stated above saves much computation.

Of course the revised rule relating to leap years has to be used with this method. Thus for January and February the year characteristic is diminished by 1 for years 04, 08, 12, 16, 20 and 24, and also for the year 00 when the century proper is exactly divisible by 4.

For the century characteristic rule (p. 828, from top, line 22 and the 14 lines following) I would substitute the following rule:

To obtain the century characteristic, divide the century number by 4, double the remainder and subtract from 6, the result will be the characteristic for the century.

The above addition to the year characteristic rule and the above substitute century characteristic rule take care of the leap years more satisfactorily than does the method of the original article. Besides, the century characteristic rule is much shorter and simpler than the one of the original article.

For dates falling within the old calendar (as explained p. 828, from bottom, line 5 and the 6 lines following), I would give the following rule:

For dates falling within the old calendar, the procedure is the same as for the modern calendar with the following two exceptions:

(a) To find the century characteristic, divide the century num-

ber by 7 and subtract the remainder from 4,[3] the result will be the characteristic for the century.

(b) The year characteristic rule is the same as above for the modern calendar with the exception omitted, all century years being leap years under the old calendar.

After the foregoing paragraphs I would add the following:

Dates can be changed from old calendar to modern calendar and from modern calendar to old calendar by the following formulas:

$$\text{Old calendar date} + [\text{century number} - (\frac{\text{century number}}{4} + 2)] = \text{modern calendar date.}$$

$$\text{Modern calendar date} - [\text{century number} - (\frac{\text{century number}}{4} + 2)] = \text{old calendar date.}$$

To these formulas there are the following exceptions:

Whichever way the given date is changed, if it is a non-leap century year according to the modern calendar, and the resultant date falls before March 1 of that year, the resultant date is varied by 1. Thus, if the change is made from old calendar to modern calendar, as in the first formula, the resultant date is decreased by 1; and if the change is made from modern calendar to old calendar, as in the second formula, the resultant date is increased by 1. For examples:

([February 17, 1800 old calendar] $+ [18 - (\frac{18}{4}+2)]) - 1 =$ February 28, 1800 modern calendar; and

([January 1, 1800 modern calendar] $- [18 - (\frac{18}{4}+2)]) + 1 =$ December 21, 1779 old calendar.

Of course for ordinary dates, those not falling within either of the variations of the formulas, -1 and $+1$ in the foregoing examples are omitted.

Since in changing from one calendar to the other the day of the week remains the same, by the above changing method we can, if we wish, find the day of the week for one calendar by using the other. This can be done by changing the date from one calendar to the other and then finding the day of the week by that calendar.

In combining the characteristics to find the day of the week, I would use a different order from that used in the original

[3]See rule following the colon, and the example at the end of the footnote, in footnote to modern calendar year characteristic rule.

article, for example the order used in the solution given on p. 829 (from top, line 5 and the 3 lines following).

To use a similar problem: What day was February 22, 1776? Using the changes of the present article to supplement the original article in finding the characteristics, I would solve the problem as follows:

22 (day)+4(month)=26; 26÷7 leaves 5; 5+4 (century)=9; 9÷7 leaves 2; 2+[4(year)−1(leap year and February)]=5, i. e., Thursday.

Finding the year characteristic last makes the mental computation of the problem easier.

In finding the day of the month, I would combine the characteristics in the order illustrated in the following solution:

To solve the problem: What days of the month did Tuesday fall upon in October, 1776? Finding the characteristics as in the previous problem, I would combine them in the following order:

1(month)+4(century)+4(year)=9; 9÷7 leaves 2; 3(day) −2=1(lowest day of the month for Tuesday in October, 1776); 1 and 1+sevens=October 1, 8, 15, 22 and 29.

For the sentence "In this case: 7+3−4=6" (p. 829, from bottom, line 3) I would substitute the following:

In this case: $7-(4-3)=6$.[4]

Some of the above suggested changes would add new matter; and the others would, I think, considerably improve the mental computation of the original article.

[4]See rule following the colon: and the example at the end of the footnote, in footnote to modern calendar year characteristic rule above.

INTERNATIONAL UNIVERSITY PROJECTED FOR PANAMA.

Laying the corner stone of Bolivarian University, Panama City, was an outstanding feature of the Pan-American Congress, assembled in June by invitation of the Government of Panama, to commemorate the one hundredth anniversary of the first All-American Congress held in the New World. The purpose of Bolivarian University is to perpetuate the ideals of Simon Bolivar in promoting and conserving peace and solidarity among the peoples of America. It is proposed that the university shall be constructed and maintained by the Government of Panama with the cooperation of representative committees from the different American Republics, and by donations from Governments and individuals. Though first efforts will be confined to a school of medicine in connection with Gorgas Institute for the Study of Tropical Medicine, the plan for the university contemplates courses in medicine, law, political science, commerce, agronomy, engineering, languages, history, literature, journalism, and philosophy.—*Dept. of Interior.*

THE AVAILABLE TESTS FOR RESULTS OF TEACHING THE SCIENCES.

By Stephen G. Rich,
Verona, N. J.

Previous to the time of writing this article (March 31, 1926), the last approximately complete list of tests available for measuring instructional results in the sciences is that of Ruch in this journal, and covering only material published previous to the middle of 1923.[1] Gerry has lately given a more adequate and critical list for chemistry,[2] and a recent bibliography on chemistry in this journal gives a few references only.[3]

The time is presumably ripe for a list which shall indicate the particular conditions under which the various tests are of use, shall indicate which tests are obsolete or no longer obtainable, and shall mention the reliability of the tests when it is known. Under some tests, references to published records of using them will undoubtedly be of value.

The following points need to be kept in mind in considering which test to use or whether to use any test at all:

(1) Relevance, or "validity of significance." No matter how good a test may be, as a measuring instrument, if it does not give the particular information which is in point, its indications are either valueless or misleading. For example, if we measure the achievement of a college-preparatory class in physics with a test on which the items have been selected without considering whether or not they are included in or are made emphatic in, such a course of study, our results will be of significance only in showing how far college-preparatory pupils are not instructed in the wider reaches of physical science. Again, a chemistry class which has been given some introduction to "modern chemistry" or industrial chemistry, but has not been drilled so extensively in the theoretical basis of the subject as is customary, will show up as "weak" on at least three of the available published tests, despite the fact that in the more interesting and presumably more useful portions of the subject they have gone far beyond the usual attainment. Similarly, where information is desired on simply the attainment in the work of the particular half-year

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[1]Ruch, G. M. Tests and Measurements in High School Science. Sch. Sci. and Math., 23; 885-891. December, 1923.
[2]Gerry, H. L. Types of Tests Desirable for Chemistry. Sch. Sci. and Math., 25; 918-922; December, 1925.
[3]The Teaching of Chemistry: Bibliography (Limited). Sch. Sci. and Math., 26; 26-28. January, 1926.

of instruction, instead of upon the total attainment or the progress since an earlier testing, only a test devised specifically for the purpose of measuring the first or the second half-year's attainment is of any usefulness.

This matter of *relevance* cannot be too strongly emphasized, since it is the lack of relevance to the purposes in hand that has made many science teachers unduly suspicious of tests and unduly inclined to stick to old-line examinations—despite the irrelevance inherent in these by virtue of the extent to which they call for ability in English composition as well as achievement in the subjects of instruction. Relevance extends, furthermore, to the degree of information tested: certain science tests, notably in chemistry, detect and measure a slight degree of retention of information sufficient to permit recognition of the correct statement of fact but insufficient to permit of making a statement beyond this. Such tests will evidently not be relevant if one desires to find out only the amount of complete retention or genuinely definite knowledge. Such tests of "recognition" as well as of "recall" are unfortunately misinterpreted as "giving chances for guessing" by those who want the more definite type of recall only.

(2) Reliability. A test is reliable when it is known to measure consistently the same results or combination of results, on repeated use with the same pupils. This may be done for either one form of test used repeatedly or for alternative equivalent forms. Reliability is expressed by a coefficient; general practice among educational measurers considers that reliability-coefficients of less than .50 indicate tests of little value. The highest reported coefficients in any field are about .90; in sciences they seldom run above .70.

(3) Availability. It is not enough that a test or set of tests be published and may be bought by packages or hundreds. Unless the equipment for using the test is convenient and adequate, little satisfactory use of it can be made. The necessary equipment for successful use of a test includes usually:

(a) Definite and full directions for giving the test, so that the procedure is kept constant.

(b) Scoring-keys, so that individual opinion in marking results is eliminated, time is saved, and accuracy secured.

(c) Norms: that is, recorded known attainments against which to measure the results with the test. A fully adequate set of norms is perhaps the most difficult item of equipment to

find, for it should include not only average scores (means or medians) but some indication of the range of scores found—and should include these for as many stages in the pupils' progress as possible within the time of applicability of the test. In general, norms exist for the end of a year or a half-year of instruction; but the usefulness of any test may be increased by having norms for many more stages, including even beginners who have never studied the science but who have picked up odds and ends of it incidentally to other studies—as they all have.

Usually all the equipment is combined in a "manual" or in a manual plus a separate scoring-key.

Many other features of desirable tests might be listed here, but to expound them and to annotate the list of tests in accordance with them would expand this article into a monograph.

I. General Science.

1. Dvorak General Science Tests. Published 1925, Public School Publishing Co., Bloomington, Ill. One form for use in the first half year and two equivalent forms for use in the second half. Reliability over .55; manual fairly complete; norms not covering a great range of times of instruction. A test of information, entirely on multiple-response method, on material within existing courses and chosen for presumed educational value.

2. Ruch-Popenoe General Science Test. Published 1923, World Book Co., Yonkers, N. Y. Two equivalent forms of test. Reliability over .80; manual unusally complete; norms for end of one school year of instruction only. A test primarily of information, with multiple-response, and completion-test sections, the latter involving recognition of illustrations. Material chosen only on basis of inclusion in existing courses, without consideration of educational values.

Not available: Caldwell-Glenn General Science Tests. Maxwell First Year Science Tests. Ruch Range of Information Test in General Science. Toops General Science Test. Barber's General Science Test. These have not been published, or are in the process of development. Full accounts of them except Barber's, of which all trace has been lost for some years, will be found in Ruch's list of 1923. Those desiring to use them will either have to secure copies from the authors or have them mimeographed.

II. Biology.

1. Ruch-Cossmann Biology Test. Published 1924, World Book Company, Yonkers, N. Y. ~~Two~~ equivalent forms of test.

Reliability about .80; manual fairly complete; norms for end of one school year of instruction only. Mainly a test of information, on material judged as legitimate by a consensus of opinion of many biology teachers. Five parts to each test: multiple-response; incomplete statements (partly involving reasoning); identification of structures from drawings; examination-type question on Mendelian inheritance; completion-test mainly on information. Only disadvantage is somewhat long time required to give the test.

2. Cooprider Biology Test. Published 1925, Public School Publishing Co., Bloomington, Ill. One form of test. Reliability not known. Manual rather incomplete; norms not too extensive. Similar to Ruch-Cossmann, but omits drawings and Mendelian question and includes reasoning test. Content substantially the same as Ruch-Cossmann test.

3. Michigan Botany Test. Published 1925, Public School Publishing Co., Bloomington, Ill. One form of test. Reliability not known; manual fairly adequate. Content that of usual high-school botany course. Four sections: true-false (as "yes-no"); best answer; matching terms to phrases; reasoning test.

Not available: Grier Range of Information Tests in Biology. Apparently obsolete; never published but must be mimeographed to use. See Ruch's 1923 list. Only recorded use since author's article on it is Rich, S. G., in Second Yearbook of N. Y. Society for the Experimental Study of Education, 1926, on using it with college freshmen in 1923.

III. Chemistry.

1. Gerry's Tests of High School Chemistry. Published 1924, Harvard University Press, Cambridge, Mass. Two equivalent forms of test. Reliability not below .60. Manual amply complete; norms for half-year and full year of instruction, with dispersions of scores indicated. Avowedly a test of information on material included in College Entrance Examination Board examinations, and entirely technical. Multiple-response questions, completion-test questions, and "choice of labelling" questions. Only disadvantage is slightly long time required to give the test.

2. Powers' General Chemistry Test. Published 1924, World Book Co., Yonkers, N. Y. Two equivalent forms of test. Reliability close to .80; manual sufficiently complete; norms for end of one year of instruction only. Mainly a test of information,

on material found in usual courses and texts, without consideration of educational values; more on applied chemistry of technological sort and on great chemists than any other published test. Two parts; multiple response; completion-test including writing of equations, giving chemical and common names, etc.

3. Rauth Foran Chemistry Tests I and II. Published 1924, Catholic Educational Press, 1326 Quincy St., Brookland, Washington, D. C. Test I for end of first half year; Test II for end of second half year. Reliability not given. Manual fairly complete though not apparently to be had in a single unit; norms for first half-year only have been seen by the writer. Test I includes "choice-of-labelling," writing symbols after names, true-false, and solving numerical problems; Test II writing symbols, completion-test, and numerical problems. More computations than any other published tests; otherwise almost purely informational. Subject-matter is the usually accepted content of chemistry courses, without any apparent regard to educational values. Reference: Catholic Educational Review, May, 1924, and November, 1924.

4. Rich's Chemistry Tests. Published 1923, Public School Publishing Co., Bloomington, Ill. Two equivalent forms of test, but named "Test Epsilon" and "Test Gamma." Reliability over .60. Manual amply complete; norms given for every quarter-year, for both high-school pupils and college freshman beginners and for pupils beyond the first year of chemistry. Entirely in multiple-response form; attempts to be one-third chemical thinking; content is all within usual courses but chosen for presumed educational values and strongly directed towards applied chemistry other than technology, the only test with any items of "modern chemistry."

References for additional or more complete norms: Rich, S. G. Achievements of Pupils in Chemistry. School Science and Mathematics, February, 1925, 25; 145-148. Rich, S. G. What Do Pupils Know of Chemistry When They Begin to Study It? Journal of Chemical Education, Aug. 1925, 2; 659-666.

5. Rivett's Time-Limit Tests in Chemistry. Published 1921 on, Byron J. Rivett, Northwestern High School, Detroit. Separate tests on the various subjects, such as formulas. Also a "Comprehensive Test," for which no published norms exist. Reliability not known; no manual published. Comprehensive test includes true-false, best-answer, problems, multiple-response, volumetric problems, equation writing. Content is entirely the usual content of courses, without any principle of selection.

Norms and directions understood to be had on application to publisher.

Reference: Rivett, B. J. A Comprehensive Test in Chemistry. SCHOOL SCIENCE AND MATHEMATICS, April, 1923. See Ruch's 1923 list for earlier references, dealing with separate sectional tests.

Not available or otherwise not for general use: Cooperative Chemistry Tests. A test for each half year's work, given orally. All data strictly local to Cleveland, Ohio. See Gerry's 1925 list. Bell Chemistry Test. Author considers it entirely obsolete. Never published separately but only in articles. See Rich, S. G., The Bell Chemistry Test, Second Yearbook, N. Y. Society for the Experimental Study of Education, 1926, for complete summary of all work on this test and earlier references. Finger's Chemistry Test. Never published. Glenn's Chemistry Tests. Instructional, not measuring, in nature. Jones' Union Chemistry Tests. Apparently obsolete, and method carried on in use by Rivett. Webb Test of Previous Information in Chemistry. Apparently obsolete. See Ruch's 1923 list. Mabee's Test of College Freshman Chemistry. Not yet published. Reference: Journal of Chemical Education, Jan., 1926. Bowser's General Chemistry Tests. Not yet published; those interested in cooperating in development of the tests may reach author, J. W. Bowser at Waynesburg, Pa. See below for Chemistry Placement Tests.

IV. PHYSICS.

1. Iowa Physics Tests by H. L. Camp. Published 1922-23, Public School Publishing Co., Bloomington, Ill. Three separate pairs of equivalent forms of tests, a pair for each of these divisions of physics: Mechanics, Heat, Electricity including Magnetism. Reliability not given; manual barely adequate; norms for each test when given at end of instruction in its subject. Largely made up of numerical problems; content that usually emphasized in teaching the subject. Questions in usual examination-type.

2. Thurstone Physics Test. Published 1922, World Book Co., Yonkers, N. Y. Reliability over .70. Manual entirely adequate; norms for end of year of instruction only. Test consists entirely of numerical problems of a pre-engineering or engineering nature. Content is therefore relevant to use with mechanically-minded or pre-engineering pupils only; obviously will not show attainment of girls.

3. Hughes Physics Scales. Published 1925, Public School Publishing Co., Bloomington, Ill. Two equivalent information tests and two equivalent numerical-problem tests called "Thought Scales." Reliability not given. Manual sufficiently complete; scoring fairly simple; norms for end of one year of instruction only. Subject-matter is the usually accepted content of physics courses, without any apparent regard to educational values. Various forms of question used in each test.

4. Black and Burlingame's Test in Elementary Physics. Two equivalent forms of test, with various forms of question on each. In process of development, and supplied free to those who will co-operate in norm-deriving, etc., by Dr. N. Henry Black, Jefferson Physical Laboratory, Harvard University, Cambridge, Mass. Definitive edition expected shortly.

Not available: Starch's Physics Test. Obsolete. Glenn's Physics Tests. Instructional, not for measurement. Jones' Union Physics Tests. Apparently obsolete. Chapman Test. Entirely obsolete. Thorndike's Completion Tests in Physics. Never published; apparently never standardized. Rich's Physics Tests. In process of development and likely to be long delayed. Hurd's Physics Tests. In active development; those interested in co-operating in development of the tests may reach author, A. W. Hurd, at University High School, Minneapolis, Minn.

For placement tests in physics see below.

V. Special Tests and Tests Not Limited to One Science.

1. Iowa Placement Examinations, in Physics and Chemistry. Published 1925, Bureau of Educational Research and Service, University of Iowa, Iowa City, Ia. In each of the two sciences there is a "Training Examination," much like Rivett's Comprehensive Test in Chemistry, on the usual content of high school work in the science, and an "Aptitude Examination," to discover special aptitude or lack of it. The latter is similar to an intelligence test but on content in or related to the science in question. Reliabilities throughout run over .85. Manual probably the most adequate for any series or test in the whole range of sciences. Norms are entirely based on freshmen at time of entering colleges. Relevance is mainly for use in sectioning classes or for vocational and educational guidance, though "Training Examinations" are probably adequate as unusually comprehensive tests upon the usual subject-matter of instruction without regard to educational values.

2. Webb Test of Laboratory Resourcefulness. Cannot be

published as it consists of a series of laboratory set-ups and directions, but partly standardized, with norms given. No record of its use except by author yet published; apparently of some value for discovering pupils who may or may not be trusted to work alone in laboratory with chance of success. Content partly from chemistry but mostly from physics.

Reference: Webb, H. S. Testing Laboratory Resourcefulness. School Science and Mathematics, April 1922; 22; 259-266.

3. Downing's Range of Information Test in Science, Revised. Published, 1921, E. R. Downing, University of Chicago, Chicago, Ill. Reliability not known. Norms recently published for middle of each year of high school. Manual exists as direction-sheet furnished by author; scoring apparently done without a key.

Reference: Downing, Elliott R. The Revised Norms for the Range of Information Test in Science. School Science and Mathematics, 26; 142-146, Feb., 1926.

4. Van Wagenen Reading Scales in General Science. Published 1923, Public School Publishing Co., Bloomington, Ill. Reliability not known; manual fairly complete; norms adequate for the purposes of the tests. Two equivalent tests. These tests serve to indicate the pupils' ability in reading various scientific material, and are intended for discovering cases in which inability to read scientific material is a cause of poor work in science. Though called "General Science" they are applicable in the field of any of the sciences.

5. Herring's Test of Scientific Thinking. Journal of Educational Psychology, 1918, vol. 9, pp. 555-558 and 1919, vol. 10, pp. 417-433. The only attempt to isolate and measure a sort of "scientific intelligence." Grade norms through high school are provided. Reliability and relevance unknown. This test is not known to be published separately, and no more recent records of its use are available. Probably will be of value in some investigation of some phase of the teaching of sciences.

AMERICAN FUR DYEING INDUSTRY LEADS WORLD.

America not only dyes her own fur collar now, but does it better perhaps than any other country in the world, William E. Austin told the recent meeting of the American Chemical Society at Philadelphia. Before the war nine-tenths of all the colored furs used in the country were dyed in Europe and those that were not, were colored with German coal tar dyes. Today, however, American tints her own and uses colors she makes herself.

About forty different dyes are used here now as compared with six about ten years ago. Every color in the rainbow scale is represented, Mr. Austin said, and novel effects in applying coloring matters are being developed. American chemists and engineers have succeeded in putting the American fur dyeing industry on the map, so that today it leads the world in efficiency, modern organization and progressive ideas.—*Science Service.*

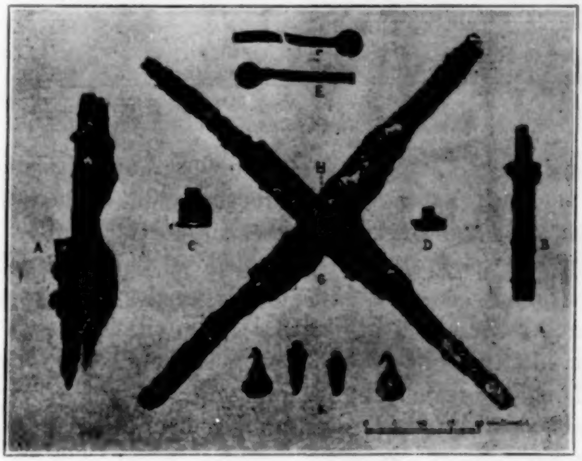
ROMAN SURVEYING.*

By Louis C. Karpinski,
University of Michigan.

In their treatises on land-surveying the ancient Romans took for granted a knowledge of the instruments employed, and left no description of them. The subject has therefore presented great difficulty; and no complete specimen of the "groma," or surveying-instrument, had been found up to 1912. A flat representation of the instrument was discovered in 1852 on the tombstone of a *mensor* (or surveyor) but it was not sufficiently clear to make a satisfactory reconstruction possible.

A mathematical reconstruction of the groma was attempted by the historian of Mathematics, Moritz Cantor, in his work, Die römischen Agrimensoren (Leipzig, 1875). While based upon correct principles from the modern point of view it was not founded upon any appreciation of the instrument itself.

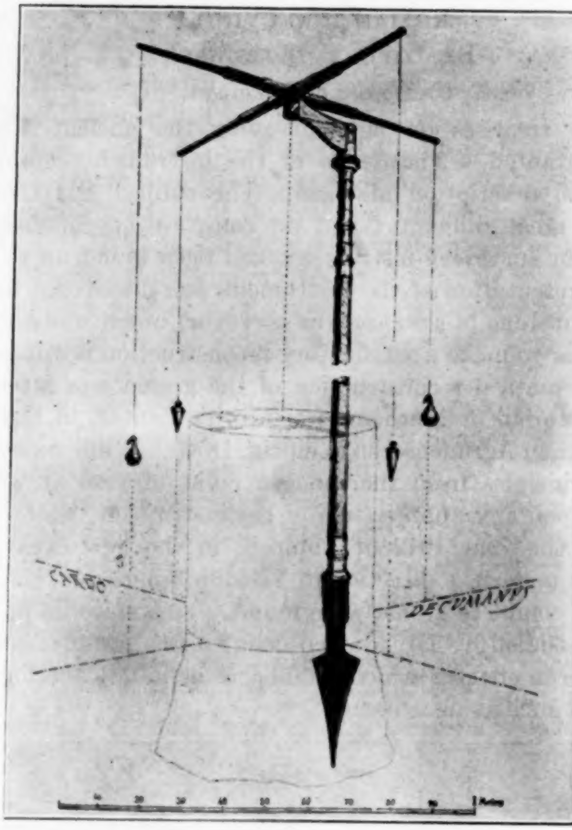
During the year 1912 at Pompeii, in the new excavations conducted under the direction of Vittorio Spinazzola, the metal parts of a complete groma were found. This material has been carefully studied by Dr. Matteo della Corte, and a reconstruction has been effected which establishes definitely the form and use of the ancient instrument.



I pezzi di ferro e di bronzo, rinvenuti a Pompei, che servono a comporre la groma.

The substantial nature of the instrument unearthed at Pompeii is indicated by the fact that the pointed foot, of bronze and iron, over 20 inches long, weighs close to eight pounds, and the upper

*Illustrations from the article by M. della Corte.



RICOSTRUZIONE DELLA GROMA.

metal piece, over 12 inches long, weighs about three pounds. Between these was a wooden support; the height of the whole was about that of a man. At the top, on a supporting arm projecting away from the rod, rotated two horizontal bars of wood, reinforced by metal; these crossed at right angles, each measuring about three Roman feet in length. From the four ends of the cross-pieces four weights, *pondera*, were suspended by long cords. The cords held vertically by the weights were used to level the instrument, and in other ways in making observations. The complete instrument probably weighed approximately thirty pounds, and was carried from place to place for the making of observations.

Throughout the empire, where surveying was necessary, the government established terminal stones of fixed dimensions and from the indicated center of these boundary stones measurements were made.

The complete and detailed description of this efficient instrument is given by Dr. della Corte in the Monumenti Antichi, Vol. XXVIII, Reale Accademia Nazionale dei Lincei (Rome, 1922) with numerous illustrations, including a reconstruction; and a number of mathematical calculations accompany the drawings, which throw light upon the working of the instrument in daily use. The remains of the instrument itself are in the National Museum at Naples.

Scholars are greatly indebted to Dr. della Corte for his clear and interesting exposition of this instrument, which is so closely associated with the famous Roman roads and in many other ways with the administration of the Roman Empire. In the same paper he has fully illustrated and explained the lesser objects which formed a part of the Roman surveyor's outfit and were found with the remains of the groma; all were in use before 79 A. D., the date of the destruction of Pompeii. The most important are the metallic ends of wooden measuring-poles; a small ivory box for little things, with the lines of a sun-dial engraved on the cover, so that the surveyor could anywhere tell the time of day, if he could see the sun; two compasses; a foot-rule; a stilus, and a small bottle for ink.

DISCOVERY OF CHEMICAL ELEMENTS DISPUTED.

Search for two missing chemical elements, reported discovered in Germany, may have to be continued. For from Russia comes word that a careful check-up on the elements, rhenium and masurium, fails to substantiate recent investigations.

In June, 1925, Prof. Walter Noddack of the University of Berlin, assisted by Ida Tacke and Otto Berg, reported that he found the characteristic X-ray spectra of the missing elements, numbered 75 and 43 in the periodic tables, in platinum ores from the Ural Mountains.

Dr. O. Zvjaginstsev of the Platinum Institute of the Russian Academy of Sciences has repeated the experiments of Prof. Noddack using rare metals from the same source and has failed to find the element No. 75 at all and considers the presence of the still rarer element No. 43 "extremely unlikely."

"The platinum was treated chemically and the X-ray spectrum photographs of the final products were carefully measured." Dr. Zvjaginstsev announced through the Scientific journal, Nature, "No. 75 would have been easily detected if it were present in the native platinum in quantities pointed out by Prof. Noddack, or even 10 or 100 times less than that. As a matter of fact, the spectrum photographs obtained prove with certainty the absence of the element in native platinum in a quantity exceeding .0003 per cent."

The discovery of this element, which is a close relative of the well-known metal, manganese, has also been claimed by Dr. J. Heyrovsky and Dr. Doleysek both of Prague, who reported that they had found it associated with manganese.—*Science Service.*

THE CONSERVATION OF ENERGY, AND THE DIRECTION OF PHYSICAL AND CHEMICAL PROCESSES.

By H. M. Reese,

University of Missouri, Columbia, Mo.

The law of the conservation of energy, in its present developed form, is not so old as we are accustomed to think. Its general acceptance dates from about 1860, and the period of development covers only the 22 years (about) preceding that date. On the other hand, the fundamental principle upon which it rests, the principle that perpetual motion is impossible, is very much older.

Parenthetically, it should be pointed out that the term "perpetual motion" is a rather bad one, for there are cases in which a never ceasing motion seems to be actually realized—for instance, the motions of the heavenly bodies, of the molecules in any material body, or of the Brownian particles;—though it is true that motions which we can control, and which can be made useful for industrial purposes, show a constant tendency to die down, even when not actually put to use.

It seems to have been fairly well understood that, if we could proceed to the ultimate conceivable limit in eliminating certain actions such as friction and air-resistance, the motion of a system left to itself—or its capability of acquiring motion—would remain unchanged; but that, even under these ideally favorable conditions, this capability (call it power, force, or energy) would diminish if any use were made of it. In other words, any industrial application implies a loss of "motion," and this is the real meaning of the statement that perpetual motion is impossible.

Even with this explanation, the statement is vague, since it fails to specify just how what is called the "motion" is to be defined. The word "energy" was not in use until a rather late day, and it was customary to use one of the words "motion," "force," or "power," to indicate what we now know as energy, but was formerly not clearly defined. It seems to have been well understood that the proper definition should include both the mass (weight) of the moving body, and its velocity, but a long controversy existed as to whether mv or mv^2 was the proper expression. It was finally agreed that $\frac{1}{2} mv^2$ is correct, and the name "kinetic energy" was given to this mathematical function.

The name force continued for some time to be used as the equivalent of energy (as in the title Erhaltung der Kraft), but gradually came to have its present meaning of an action which

changes the velocity, rather than the accomplished result of such an action. Force, unlike energy, is a vector, and it is measured by the product of the mass of the body upon which it acts and the rate of change of velocity which it produces in that body.

The difference between the two concepts force and energy, in our present nomenclature, is very great. Energy may be regarded as a possession of a body or group of bodies, while force is an episode or action in which two bodies must be concerned. The two magnitudes depend in quite different ways upon the fundamental units of length, mass and time, so that a force and an energy that are numerically equal could be made to take unequal numerical values by simply changing the unit of length, say from the centimeter to the foot.

The better understanding of the nature of forces, brought about largely by Newton's work, prepared the way for the establishment of the principle of the conservation of energy so far as ideal mechanics, free from friction and fluid resistance, is concerned. The forces of this ideal mechanics are of the kind known as "conservative," that is, the force acting upon a body depends only upon its position with respect to other bodies,—or roughly speaking, the rate of change of a body's velocity is always the same when its position is the same. Under these circumstances, it can be proved that its kinetic energy will also depend only upon its position. Suppose then that a body passes from a position A to another position B, thereby gaining, from the force-actions in the field, a certain amount of kinetic energy. Then if it returns to the point A again, it will lose precisely this same amount of kinetic energy. Then we may say that in position A it has a certain advantage over position B, since in giving up the former position for the latter it receives as compensation a certain amount of kinetic energy. It was then a natural step to introduce a new type of energy, "potential energy," to express this advantage of position, and when this is done we have, for ideal mechanical systems, the general law that the sum of the two types of energy (K. E. + P. E.) is constant.

In actual mechanical systems, where non-conservative forces such as friction are effective, the sum K. E. + P. E. does not in general remain constant, but usually decreases. In practically all such cases there is an evolution of heat, which accompanies the loss of energy, and which was early believed to represent that loss in some way. The hypothesis that heat is a form of irregular motion in the interior of matter is a very old one, and

it would seem natural enough to identify the heat produced by friction, etc., with the apparently lost mechanical energy, and to seek experimentally for numerical relations between the two. But the motion theory of heat went decidedly out of fashion, and it became quite generally believed that heat is an indestructible and uncreateable material.

The revival and development of the motion theory was largely stimulated by a believer in the material theory, Sadi Carnot, in a discussion of the steam engine. According to the material theory all the heat supplied to the steam in the boiler must be given up in the condenser, just as all the water which enters at the top of a water-wheel is discharged at the bottom. Carrying out this analogy, Carnot assumed that the work done in the engine was proportional to the product of the heat carried by the steam from boiler to condenser, and the difference in temperature between the two. Heat flows from high to low temperatures doing work, just as water flows from high to low levels doing work.

Shortly before his death, Carnot seems to have realized that his assumption was false. Apparently, one of the considerations that led him to question it was the following: If heat in passing through the intermediate agency of steam, from a higher to a lower temperature, does a certain amount of work, increasing the amount of energy in other bodies, what becomes of this possible amount of work when heat flows directly from high to low temperature by conduction?

As a matter of fact, the analogy between the flow of heat and the flow of water is fundamentally false. While it is true that heat flows only from high to lower temperatures, water can flow either to higher or to lower levels. Whenever a garden hose is pointed upward we may see water flowing upward against gravity. It may be objected that it is only inertia that carries the stream upward, its natural direction of flow being downward. But it is just here that the analogy breaks, for there is no such thing as inertia in the flow of heat. A perfectly elastic ball, dropped from a height upon a perfectly elastic floor, in a vacuum, would go on rising and falling indefinitely, but there is nothing like this in the flow of heat.

The force of gravity upon any material is not energy, but the product of that force and the distance fallen is energy. On the other hand, the labors of Joule, Mayer, and others show that heat itself, not multiplied by any other physical magnitude, is

energy; and the unit of heat (the calorie) is a unit of energy, differing from the erg or the foot-pound only by a numerical factor, as the foot differs from the centimeter. In the case of the steam engine, the heat given up to the condenser is less than that supplied from the furnace, the difference being exactly equal, when multiplied by the proper factor, to the work done in the engine.

The recognition of the real nature of heat hastened the completion and the full acceptance of the energy principle. The energy relations of electricity and magnetism, though they involve more mathematical difficulty than those of thermal phenomena, are easier of conception, partly because electrical and gravitational phenomena are more closely analogous. Unlike heat, electricity is not energy, and the coulomb, unlike the calorie, is not a unit of energy. Electrical quantity multiplied by another factor, potential, gives energy. For magnetism, an entirely analogous relation holds true.

To my mind the principle of the conservation of energy is purely and simply empirical, and has no claim to an a priori character. I have heard students of philosophy speak of a necessary "quantitative identity" in nature, as synonymous with the conservation of energy, but it seems to me that what they have in mind is something very much broader and less precise than this physical law,—something which they cannot formulate in language that admits of numerical values and therefore is not really quantitative.

In the mind of the layman, I think the principle is regarded as a sort of self-evident truth, but he really doesn't know what the principle is. Among working scientists, it is now accepted absolutely without question, even though the Newtonian mechanics, far older, is now partly discredited. As an example of this confidence, take the case of radio-activity, where small quantities of matter give off energy at a relatively enormous rate, without any other change than a slight decomposition. In order to prove, what is generally assumed without question, that this minute decomposition really implies a loss of internal energy which is equal to the large amount of energy set free, it would be necessary to either reverse the radio-active process, showing that in order to put the substance back into its original condition this same amount of energy must be supplied to it, —or else materially alter the character of the decomposition, and show that for the same final result the same amount of energy is

set free. But radio-active processes are absolutely irreversible, and also entirely unalterable by any physical or chemical agency. No one now suspects that they are at all in disaccord with the energy principle, but if radio-activity had been discovered sixty years ago it would quite possibly have been a serious stumbling-block in the way of the acceptance of the conservation of energy.

At any rate the principle works, we know of no case where it breaks down, and we are probably justified in regarding it as one of the greatest and most universally applicable of all natural laws.

What I want to point out in the rest of this paper is its insufficiency. It predicts no phenomena, but merely serves as a condition. In fact, if it were the only principle of nature, probably nothing would ever happen at all. As an example, take a case that has already been cited, the tendency of heat to pass from warmer to colder bodies, a tendency which is universal, and without which the concept of temperature would be impossible, except perhaps as a mere bodily sensation. The energy principle says only that when two bodies are in thermal communication the heat lost by one is gained by the other—nothing at all about the direction of heat-flow. According to it alone, there would be nothing to prevent a can of milk set within a vat of molten iron from growing colder and colder till it froze, while the iron boiled away.

As a further example, take the dissolving of sugar in water. This proceeds automatically up to a certain concentration, a little heat being evolved during the process, and then stops. There is nothing, so far as the energy-principle is concerned, to prevent the solution going on to an unlimited extent, more heat being evolved;—or on the other hand, there is no reason why, starting with a sugar solution, the sugar should not completely crystallize out.

There is nothing in the energy principle to forbid the construction of an engine which could drive a vessel from New York to Liverpool without fuel, by simply drawing heat from the sea. The energy used in overcoming the head resistance of the water would return to the sea again in the form of heat, so that at the end of the voyage the sea would be no poorer in energy than at the beginning, and the vessel no richer.

It lies within the very nature of the energy principle that it is unable to predict phenomena, for it can be stated in the form of an equation, and the two members of an equation are of equal value. Very evidently, a principle which undertakes to predict

which of two possible directions a given phenomenon will take must, when expressed in mathematical language, have the form of an inequality, that is it must be a statement that something must always increase with the time, (or *decrease*, according to the way in which that something is defined). This fact, that we are to deal with a one-sided relation instead of an equality, makes the subject more difficult than the energy principle, not only in formulation, but also in appreciation of its significance. A function which always increases (or decreases) must from its very nature seem to be tinged with an element of unreality as compared with one whose total value in the universe remains constant.

Probably chemists have realized the need for some such auxiliary principle earlier and more acutely than any other scientific workers. At any rate, the chemist Berthelot proposed such a principle in the very simple law that chemical reactions always proceed in such a way as to set free energy in the form of heat. Unfortunately the statement is absolutely false, for it is easy to cite cases against it. Moreover, most, and probably all processes, never proceed to completion, but reach a point of equilibrium and then stop. The example of sugar dissolved in water is a case in point. Hydrogen and oxygen gas combine with a great evolution of heat to produce water-vapor, but a definite amount of free oxygen and hydrogen is always left.

The problem was finally solved by Thomson and Clausius as a result of a reconsideration and reconstruction of Carnot's steam-engine theory. The new principle which resulted is called "The Second Law of Thermodynamics." It has been stated in several ways, of which the following, due to Planck, is probably the best: "It is impossible to construct a periodically working machine which has no other effects than the raising of a weight and the cooling of a heat-reservoir." A simpler statement, due to Clausius, is the following: "Heat cannot, of itself, pass from a colder to a hotter body." This law is strictly empirical, like the law of the conservation of energy, but it is entirely independent of the latter. All attempts to derive the one from the other have failed.

The second law permits the formulation of a new mathematical concept, the *entropy*, a function whose definition I shall not give here, but whose fundamental property may be stated as follows: In any process, chemical, physical, or otherwise, the sum of the entropies of all bodies affected either increases, or, in limiting

cases, remains constant. Processes which do not provoke an increase in entropy are "reversible," all others "irreversible." It should be explained that in order for a process to be reversible it is not necessary that it be capable of exactly retracing itself. It is sufficient if, by any means whatever, all its effects can be undone, leaving no trace anywhere in the universe.

No example can be given of a strictly reversible process, unless the motions of the heavenly bodies, and intra-atomic processes, be such. On the other hand, it is easy to imagine ideal processes which are reversible, such as purely mechanical processes free from friction.

Examples of irreversible processes are the dissolving of sugar or salt in a liquid, the mixing of two or more gases, the production of heat by friction, the breaking of an egg, any explosion, the burning of coal, etc., each of which involves increase of entropy. Every industrial process increases the entropy of the universe, often at a very rapid rate.

From the illustrations of irreversibility here given, it will be noticed that increase of entropy can occur without any phenomena involving heat, or any manifestation of energy whatever (as in the mixing of gases), although in most such cases the change of entropy can be evaluated in terms of an indirect hypothetical process which would lead to the same final end and *would* involve heat-transfer.

The main value of the entropy-principle is that it enables us to predict states of equilibrium. Since entropy always tends to increase it is clear that equilibrium will be reached when, and only when, the entropy of the system has attained its greatest possible value, under the given experimental conditions. The fact that stable equilibrium requires a maximum of entropy has proved of immense importance in the study of physicochemical relations.

The two principles, of constancy of energy and of increase of entropy, together suffice to determine the direction which any physical or chemical process takes, provided that the initial conditions of the system concerned are fully given, and we are able to evaluate the energy and the entropy. Nevertheless, even the two of them are not capable of completely predicting any phenomenon. For instance there is no general principle which predicts *how fast* the entropy will increase.

The ultimate nature of entropy, and of irreversible processes, was from the first a very puzzling thing. According to the

strictest mechanistic view of nature, which requires that every phenomenon is ultimately explainable in terms of the motion of material particles under the simple laws of mechanics, every process would be reversible if we had the power to direct the motion of each particle. For instance, if our perceptions and ability were fine enough so that we could introduce suitable reflecting walls in the paths of particular molecules, we could, without violating the conservation of energy, or the other laws of mechanics, separate a uniform mass of gas into a warmer and a cooler portion, and so violate the second law.

In fact, the second principle depends, for its usefulness and even for its existence, upon the limitations to human intellect, human sense-perception, and human technical skill, and these limitations should be constantly borne in mind in any discussion of it. To explain the meaning of this statement, take the example of a mass of gas, enclosed in a container of fixed volume that is impervious to heat. In order to know completely the condition of the gas, it would be necessary to assign a name, number, or other designation to each molecule and to be able to tell where each one is and what its speed and the direction of its motion, a hopelessly impossible task. What *can* we know about the molecules of a gas? Only a few things, as follows: First, we could pick out small samples from every part of the container, possibly samples as small as a cubic millimeter, and find the mass of each sample. Thus we might find the number of molecules per unit volume in every region, averaged in each case over a volume that to us seems very small, but yet is large enough to permit considerable undetected variations in density within the region. Second, by sticking a very small thermometer into different parts of the container, we could determine the temperature distribution. According to the kinetic theory of gases, this would give the average kinetic energy of the molecules in different regions; but here also the average would be extended over a great many molecules for each region, millions at the least. Finally, we could determine whether there are eddies anywhere. But an eddy is only a predominating velocity in one direction or another, giving no information about the direction or speed of a single molecule. The second principle of thermodynamics tells us that after a sufficient lapse of time, every small region (say each cubic millimeter) will contain the same density of molecules, the average kinetic energy in the molecules of each will be the same, and there will be no percep-

tible stream-motions, or eddies. This condition gives the maximum entropy for a given volume and energy.

To our sense-perceptions, all samples of a given gas, for instance hydrogen, which have the same volume, mass, and energy, and in each of which density and temperature are uniform and eddies have ceased to exist, appear identical. We cannot distinguish between them because such gross phenomena as density, temperature, pressure, and local streaming are the only things by which we *could* distinguish them. Nevertheless such samples may, and almost certainly will, differ among themselves enormously in the details of molecular configuration and velocity. Furthermore, any one of the samples will at different times vary greatly in these respects without showing any perceptible variation to our senses. As a matter of fact there are vastly more possible differences in molecular configuration that are compatible with uniform temperature, density, etc., than are compatible with any state in which we can detect variations in these quantities. The case may be put crudely in this way: Imagine a tremendous number, say a billion of gaseous systems, each having the same number of molecules, the same volume, and the same total energy, but otherwise differing entirely at random in the arrangement of molecules and their velocities. Then the overwhelming majority of these systems would, when tested by any of our experimental methods, appear identical, each seeming to be uniform in density and temperature, and free from eddies. Only a relatively small number of the systems would appear to us to differ from one another, because the great differences that would actually exist among the majority would be differences which we could not perceive.

Herein lies, according to our present views, the real meaning of irreversibility and entropy. The gas tends toward uniformity in such details as we can observe, simply because such a condition is far more common than any other, or rather more *probable*, using the word in the sense in which statisticians use it. An increase of entropy then means a passage from a less probable to a more probable condition, and therefore entropy must be, as a numerical magnitude, a function of the mathematical probability. In fact, for such cases as permit the calculation of the probability, the entropy comes out to be a constant factor times the logarithm of this probability.

To a person of such small dimensions and acute senses and intelligence that he could perceive and attend to the position

and velocity of every molecule, there would be no reason in considering such things as temperature and density, which are only averages taken over a space which is to him very large though to us very small. Conditions of a gas that to us appear identical would to him be very different and he would see no sense in grouping them together. If he knew the complete arrangement of a gas at any one time, to him there would be exactly the same chance for it to be in any other specifiable arrangement a week later, but to us the chance for it to be in a special condition (uniformity) would be very great, because what we mean by uniformity includes what to him are a great number of different arrangements.

As an example: The chances of throwing a total of six with a pair of dice is 5 times as great as that of throwing 2, for six can be thrown by any one of the combinations 1-5, 2-4, 3-3, 4-2, 5-1; while 2 can be thrown only by the combination 1-1. But to a person who is looking, not for a total of 6, but for a definite combination that would produce 6, say 1-5, this would be no more probable than the 1-1.

This relation between entropy and probability was first worked out by Ludvig von Boltzmann. An excellent presentation of it was given in a series of lectures delivered at Columbia University by Max Planck, in 1909. If the theory is correct, then we must modify the second law slightly. Instead of saying "entropy cannot decrease," we must say "it is highly improbable that entropy will decrease." (Certain slight fluctuations, involving small temporary decreases of entropy, about an equilibrium condition, are really allowed for by the theory, and are observable in special cases).

When we read in the Bible that Gideon found on one morning that a fleece lying on the ground was soaked with dew while the ground was dry, and next morning that the reverse of this phenomenon occurred, we cannot say "This is against the laws of Nature" but we can say "This is in a high degree improbable, and we are not convinced."

The universe appears to be like a clock that was wound up and is running down. Every change we can observe, except for minute fluctuations, involves an increase in entropy, a passage into a *more probable* state. Will it continue in this way until the only changes that occur are those of the chance grouping of molecules, or will it some time be wound up again? It seems to me that, although the winding up would be a highly improbable

occurrence, yet in long enough time the very improbable thing may happen, and time may be very long.

The existence of irreversible phenomena, the second principle of thermodynamics, the concept of entropy, and indeed such concepts as temperature, fluid pressure, fluid density, and heat are human devices to bridge over the limitations of man's mind, enabling him to acquire gross knowledge where detailed knowledge is impossible. They serve their purpose well, and the gross knowledge is for many purposes all he wants.

DISCUSSION OF FORCE, MASS AND ACCELERATION.

By Wm. S. Franklin,

Massachusetts Institute of Technology, Cambridge, Mass.

Unquestionably it is best to define the mass of a body as what you get when you "weigh" the body on a balance scale. This result is called *weight* in everyday life, and therefore the word weight as used in everyday life has precisely the same meaning as the word mass as used in scientific writing. Let us pay no attention to the spring scale.

Engineers agree to use the word *weight* to designate the force with which the earth pulls on a body; and nearly all engineers carelessly revert to the usage of the coal-man and speak of the result obtained by weighing on a balance scale as *weight*, forgetting that the balance scale (which gives the same result everywhere) does not measure the weight of a body in the force sense. This is a fact. If you travel with a ham and a balance and a set of weights you will get the same result everywhere when you "weigh" the ham, whereas the pull of the earth on the ham is not the same everywhere.

Most of the confusion in the use of the word weight comes from the fact that the word has two distinct meanings, its popular meaning which is the same as *mass* and its technical meaning which is *the pull of the earth on a body.*

Likewise the word *pound* has two meanings, it is the name of the English commercial unit of mass, and it is the name of the English engineer's unit of force (the pull of the earth on a one-pound body at 45° north latitude and at sea level); and to avoid confusion we should speak of the "sugar-pound" or "ham-pound" (the unit of mass) and of the "pull-pound" (the unit of force).

Let the reader understand that this article is not a line of argument—it is a statement of facts, and we will never get out of the prevailing confusion in elementary mechanics until widespread prejudices give way to these facts, never.

Many teachers of elementary mechanics believe that the laws of acceleration can be most easily given to a student by using the formula

$$F = \frac{W}{g} \cdot a$$

or

$$\frac{F}{a} = \frac{W}{g}$$

or

$$\left\{\begin{matrix}\text{the acceleration}\\ \text{due to a given}\\ \text{force}\end{matrix}\right\} : \left\{\begin{matrix}\text{the given}\\ \text{force}\end{matrix}\right\} :: \left\{\begin{matrix}\text{the acceleration}\\ \text{of gravity}\end{matrix}\right\} : \left\{\begin{matrix}\text{the weight}\\ \text{of the body}\end{matrix}\right\}$$

and this point of view is easy because it seems to avoid the confusion which comes from the double meaning of the word weight, and the double meaning of the word pound; but the term "weight" in this formula means the earth pull on a body which is *not* what you get when you weigh the body on a balance scale, whereas everyone in using this formula takes for W the result you get from weighing on a balance scale! Professor E. V. Huntington of Harvard University is the only writer on mechanics who avoids this fallacy in using the above formula, and you will find it at least as difficult to follow Professor Huntington's entirely correct logic as you will to follow the logic of Lord Kelvin and P. G. Tait which underlies the point of view that prevails almost universally among physicists.

Professor Huntington rightly states that wherever you may be the result you get by weighing on a balance scale is what the body *would* weigh (in the force sense) at the standard locality. This is what Professor Huntington uses for W in the above formula, and for g he uses always the precise value of g at the standard locality. This is not incorrect, and yet the result of weighing on a balance scale is independent of locality and to refer this result to a standard locality is to bring into consideration something which has absolutely nothing to do with the matter in hand. This is the chief objection to Professor Huntington's point of view, and another objection is that Professor Huntington's point of view is not in conventional agreement with the point of view which is almost universal among physicists. Conventional disagreement is of course a very different thing from fallacy, and yet conventional uniformity is of very great practical importance. It is pretty nearly certain that Professor

Huntington's term "standard weight" will never supplant the term "mass" in scientific writings.

But what is the point of view of Kelvin and Tait? In the first place this point of view recognizes that 10 pounds of sugar is 10 pounds of sugar independently of location, which, of course, every one now recognizes, and in the second place the Kelvin-Tait point of view recognizes the experimental fact that the acceleration produced by a force is proportional to the force[1] and inversely proportional to the mass of the body on which the force acts (as an unbalanced force). Furthermore physicists are agreed to use as the c. g. s. unit of force the force which will accelerate a gram at the rate of one centimeter per second per second so that if c. g. s. units are used we have the familiar equation:

$$F = ma \qquad (1)$$

where a is the acceleration in cm. per sec. per sec. produced when an unbalanced force of F dynes acts on a body whose mass is m grams.

There is some advantage in using equation (1) when F is expressed in pull-pounds and a in feet per sec. per sec., but then m cannot be expressed in sugar-pounds; *the necessary unit of mass is the amount of material which will be accelerated at the rate of one toot per sec. per sec. by an unbalanced force of one pull-pound.* This unit of mass is called the *slug* and it is equal to 32.1740 sugar-pounds. Mass in sugar-pounds must be divided by 32.1740 (a pure number, *not* an acceleration) to reduce to mass expressed in slugs.

Why is the slug equal to 32.1740 sugar-pounds? Because the earth pull on one sugar-pound at 45° north latitude and at sea level (the true and exact pull-pound) is found by experiment to accelerate the sugar-pound at the rate of 32.1740 feet per second per second and if we were to make the mass 32.1740 times as great the same force (a pull-pound) would accelerate the increased mass $\frac{1}{32.1740} \times$ 32.1740 ft. per sec. per sec. or at the rate of one foot per sec. per sec.

If the pull-pound is used as our English engineers' unit of force (and it is so used almost universally), and if the corresponding unit of mass, the slug, is defined as above stated, then, of

[1]This statement assumes that forces can be measured by other than their accelerating effects which is true although the fundamental method of measuring forces is now, by agreement, to measure them in terms of their accelerating effects.

course a complete systematic scheme of engineers' units can be defined in terms of the foot, the slug and the second. This scheme of units is called the foot-slug-second system (the f. s. s. system). This scheme of units is framed up in exactly the same way as the c. g. s. system, and the very great advantage of the f. s. s. system grows out of the fact that either system of units, c. g. s. units or f. s. s. units, can be used in any formula in mechanics when the formula is in its simplest form. No change in any formula need be made if one wishes to shift from c. g. s. units to f. s. s. units.

A curiously absurd situation comes about when the equation $F = \frac{W}{g} \cdot a$ is used as the basis for the development of elementary mechanics, namely, the symbol g appears in every formula in mechanics which expresses a dynamical relation which is absolutely independent of the pull of gravity, and the symbol g is absent from every formula in mechanics which expresses a dynamical relation which is really dependent on the pull of gravity! This absurd situation was pointed out many years ago by Lord Raleigh.

AN ANALYSIS OF FRESHMAN COLLEGE MATHEMATICS.

By Prof. E. E. Watson,

Iowa State Teacher's College, Cedar Falls, Iowa.

The question is frequently raised as to why college freshmen find mathematics difficult. In order to discuss this intelligently let us examine not only the course itself but the amount and nature of the material in geometry that is assumed as a foundation for freshmen college mathematics. In elementary geometry we find certain features such as: 1. The vocabulary; 2. The basic ideas; 3. The theorems.

The expression "basic idea" is here used to mean a fact or group of elementary facts, a knowledge of which is necessary for a definite concept of the theorem under consideration. Thus the statements: "A point has only position," "A line-segment is any part of a line," "A triangle has three sides," "The sum of the acute angles of a right triangle is 90°," are called basic ideas. In the latter statement it is necessary to know what acute angles are, what a right angle is, what a triangle is, and that the sum of all the angles is 180°, a group of elementary facts.

An analysis of recent texts on high school geometry indicates that such a book contains:

1. A semi-technical vocabulary of 600 words, such as abscissa, arc, complement, diagonal, function, initial, locus, maxima, obtuse, projection right, sine, trisect, variable, =, etc.

2. Two hundred seventy-five basic ideas such as:

1. A minor arc is the smaller of two unequal arcs of a circle,

2. Concentric circles have the same center,

3. There are 360° in a circle.

3. Seventy theorems which most geometries contain and which for convenience are here called "essential theorems."

4. Forty theorems in which there is considerable variation in the selection.

Of the above named material what part is used either directly or indirectly in freshman college mathematics during:

(a) The first quarter, three months.

(b) The second quarter, that is not used during the first quarter.

(c) The third quarter, that is not used during either of the other quarters.

(d) How much new material is used each quarter?

An Analysis of the First Quarter's Work.

A careful tabulation indicates that the college freshman taking a course in unified mathematics at the Iowa State Teachers College uses of the above named material during the first three months:

(a) 320 Semi-technical words or 53 percent of them.

(b) 154 of the basic ideas or 56 percent of them.

(c) 51 of the essential theorems or 73 percent of them.

In addition to the above named material the student must use:

(a) 600 semi-technical words, not found in geometry such as, acceleration, bearing, co-function, dip, exponential, graph, inclined, latus rectum, moment, radian, synthetic, x-axis, etc.

(b) Seven theorems, not among the essentials.

(c) Formulas and processes used in connection with the topics, graphs, numerical side of trigonometry, logarithms, straight line, quadratic equation, slope, maxima and minima, theory of equations.

An Analysis of the Second Quarter's Work.

The second quarter's work is so organized that by the end of this term the student has completed his college algebra, trigonometry, the straight line formulas of Analytic geometry and has had both differentiation and integration. The term's work may be summarized as follows:

(a) Semi-technical words used in geometry, but not used in freshman mathematics during the first quarter.................. 32
(b) Words not used in geometry or in the first quarter's work..500
(c) Basic ideas not used in first quarter.................................. 14
(d) Essential theorems not used in first quarter.................... 14
(e) Theorems not among the essential theorems..................... 8
(f) Formulas and processes of the quarter's work.

An Analysis of the Third Quarter's Work.

During the third quarter the analytic geometry is completed Some attention is given to complex numbers, polar coordinates, statistics, differentiation and integration. This term's work may be summarized as follows:

(a) Semi-technical words not used in the work of the first or second quarter, 300.

(b) Theorems of geometry which deal with the cube, rectangular solid, cones, spheres, parabolas, ellipses, hyperbolas.

(c) Formulas and processes of the course.

By the time the student has completed the work of the third quarter he has had occasion to use, either directly or indirectly:

(a) 350 of the semi-technical words of plane geometry.
(b) 168 of the basic ideas.
(c) 65 of the essential theorems.
(d) 15 theorems, which are not among the essentials.
(e) 1400 new semi-technical words.

Of the 70 essential theorems the following are not used or only rarely occur in this course:

1. Intersection of chords within a circle.
2. Perimeters of two similar polygons.
3. Test for similarity of polygons.
4. The sum of the exterior angles of a polygon.
5. The bisector of an angle of a triangle divides the opposite side into segments proportional to the adjacent sides.
6. The bisector of an exterior angle of a triangle divides the opposite side externally into segments proportional to the adjacent sides.
7. An angle formed by two secants, two tangents or a tangent and a secant equals in degrees one-half of the difference of the intercepted arcs.

The theorems here called "essential theorems" correspond very closely to the ones recommended by the national committee.

From the above data it is evident that a fair knowledge of plane geometry, vocabulary, basic ideas, theorems, is one of the essentials to success in freshman college mathematics.

A PRELIMINARY REPORT ON THE PROGRESS AND ENCOURAGEMENT OF SCIENCE INSTRUCTION IN AMERICAN COLLEGES AND UNIVERSITIES, 1912-22.

By N. M. Grier,

Des Moines University.

(Continued from October)

General Biology.

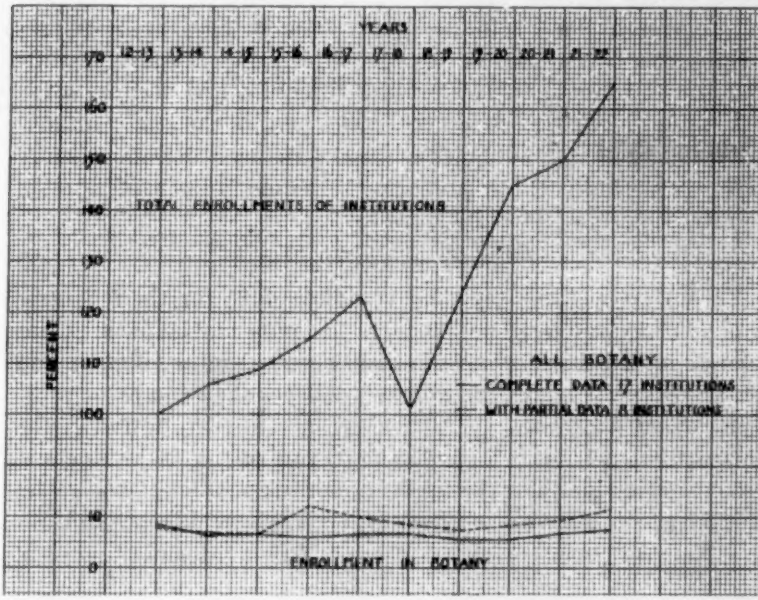
Ten institutions furnished complete data for this subject, while seven furnished only partial data. Nine institutions show an increase in enrollment, seven decrease, one having no change. Three of the women's colleges show an increase, two decrease. The greatest increases are, in order, in the New England Men's Colleges, the southern institutions, the western institutions, and the New England Women's Colleges. The northern institutions show a distinct loss. The graph indicates that during the ten year period, the total enrollment in the institutions considered increased 150 per cent but the one graph indicates a distinctly downward trend for the subject itself, especially since 1920. Enrollment in general biology was greater before the war than it has been since. Immediately afterward, however, a distinct rise occurred when the courses in military hygiene, etc., which had replaced it during the war, were taken from the curriculum.

General biology perhaps shows the greatest variation in subject material of any of the collegiate courses in beginning science, possibly because it has been subject to severe attack on the part of biologists themselves. On the other hand the variation in the types of course referred to may indicate a keen appreciation of the possibilities of this composite science. There is surely much to be said for a subject which views all life in unity, bringing out its various phases by comparison and contrast. Hence it seems well adapted to the single year of study most students give it in college, if the content is such as to avoid so far as is possible subject matter the student may have previously had.

All Botanical Sciences.

With this subject is included the enrollment in agriculture at certain institutions because the data for the latter was indistinguishable from that of the purely botanical courses. Seventeen institutions furnished complete data for botany while eight had only partial data. Ten show an increase in enrollment while fifteen show a decrease. Two of the Southern women's colleges show an increase while the decreases are found mostly in New

England. Only the southern group of institutions show an increase and the decreases in order from the least to the greatest loss are found in New England Women's Colleges, northern and western institutions and New England Men's Colleges.

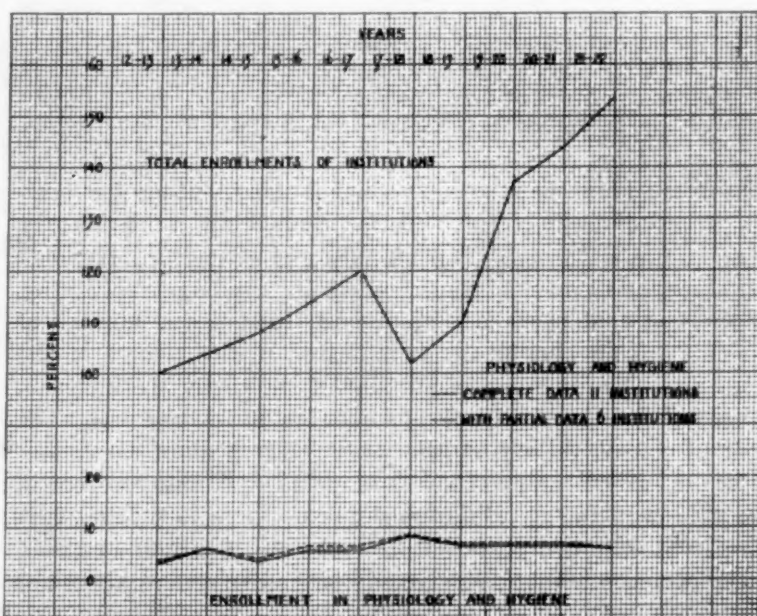


The graph indicates that while the total enrollment of the institutions represented has increased 65 per cent the complete data for seventeen institutions shows that there has been a loss of at least 1 per cent over the period studied. Further indications of the graph are that as a general thing, botany has been in a process of decline over the period studied but at present may be on an upward trend. The admixture of agricultural students introduces an element of confusion which may be possibly offset by the fact that there is a downward trend in the number of students taking agriculture as indicated in the résumé of the literature. The increase in enrollment shown by the inclusion of partial data in the graph is somewhat at variance with the data cited from the report mentioned. The peak of enrollment in botany, when the partial data is included, is seen to occur in the year 1915-16, a circumstance possibly due to the fact that during the next two years war time conditions largely curtailed biological instruction. Surely no science has more abundant illustrative material in interesting phases than botany. One

prominent botanist remarked to the writer that he had been warned he would lose "caste" if he concerned himself so prominently with the teaching problems of the science. But not all botanists feel that way as shown by the variety of good textbooks on the market, and the clever teaching devices invented by progressive ones. Botany is far from being a molly-coddle science when in the hands of a capable teacher. It is also possible that the enrollment in botany has suffered a loss because some institutions have required in the past a year in the study of general biology as a pre-requisite, when advanced botanical study may attract only those preparing to some branch of applied botany such as agriculture, forestry, etc.

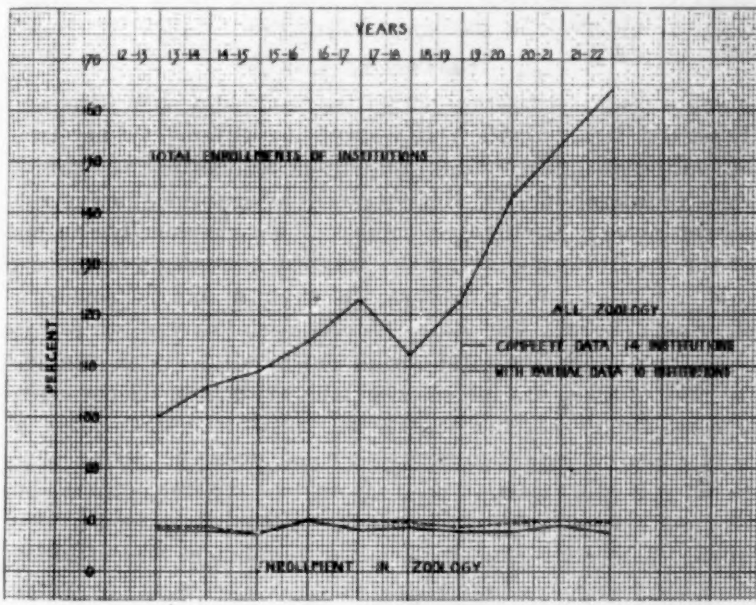
Physiology and Hygiene.

Eleven institutions reported complete data for their courses in physiology and hygiene; six furnished only partial data. Considered *in toto* seven of these show increases in enrollment and ten decreases. Four of the women's colleges show increases while four exhibit decreases. The greatest increases are found in the southern women's college group, followed by the New England Women's Colleges and the western institutions; while the group of institutions showing a loss in order are northern institutions and New England men's colleges. The total enrollments of



the institutions considered gained 54 per cent, while the graphs indicate an increase of from two to three per cent in the enrollment in physiology and hygiene.

Instruction in physiology and hygiene reached its peak by the end of 1917-18 which may be due to the introduction of courses in military hygiene into the curriculum in response to war needs. The small number of institutions reporting courses in this subject may indicate that it is gradually passing from the college curriculum, the practical hygiene phase of it being best cared for by the department of physical education and hence not reported on the questionnaire. It is questionable whether any better place should be provided for it in the colleges in view of the extended health conservation activities inaugurated by the public schools.



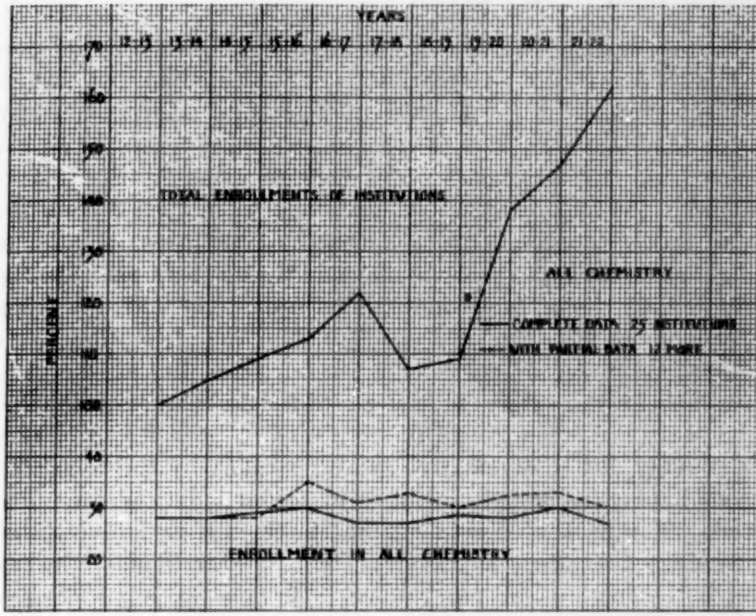
All Zoological Sciences.

Twenty-four institutions contributed complete or partial data for this subject. Of these, nine show an increase in enrollment, twelve a decrease, three no change. Four of the women's colleges show an increase and two decreases, one no change. Institutions gaining are, in order, the northern and western institutions and the southern institutions; while the losses, in ascending order, are the New England men's and coeducational colleges

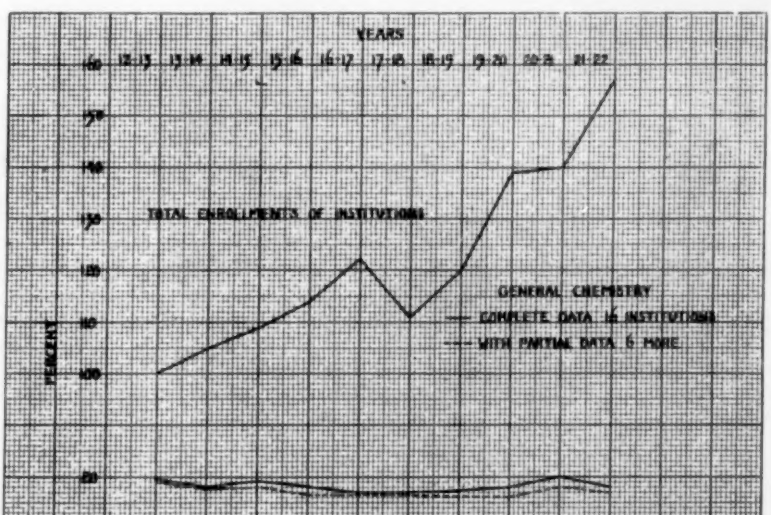
and the New England women's colleges. The graph indicates that in the ten year period, the total enrollment in the institutions considered had increased 64 per cent. If all the data from the twenty-five institutions be considered, zoology shows about a 1 per cent gain for the period; but if the complete data from only the fourteen institutions be considered, zoology has lost that amount. The peak of enrollment was attained in the year 1915-16, a circumstance possibly due to the fact that during the next two years war time conditions largely curtailed biological instruction. Here, as in botany, the introduction of a pre-requisite year of general biology may militate against students electing advanced zoological subjects, which after all attract mostly pre-professional students of one type or the other. It is true also, that various popular magazines cover those fields in zoology of most interest to the layman, and which ordinarily are not provided for in zoological instruction.

All Chemistry.

Twenty-five institutions submitted complete data; twelve, only partial data. Of the thirty-seven institutions, twenty-two show an increase, fifteen a decrease in enrollment for the years under consideration. Of the women's colleges included eight show an increase and three a decrease. Geographically considered the institutions showing the greatest increase in order, are the New England men's colleges, the western, and the southern institutions. From the study of the accompanying graph, it is seen that while the total enrollment of students in the institutions studied has increased on the average of 62 per cent, the complete data from twenty-five institutions indicates a loss of 1 per cent in chemistry as a whole over the period considered. If the partial data from the twelve others be considered in addition, chemistry has gained 3 per cent. The graphs also indicate that the peak of enrollment was attained during the years of the war when, of course, interest in chemistry was at its height. The other unquestionable peak is for the year 1920-21, which may or may not be correlated with the increasing number of students attending college and the closer connection with every day life which chemistry seems to enjoy above all other sciences. Many professors of chemistry in the colleges and universities are inclined to discourage students from majoring in their science unless they also plan to train themselves for teaching, believing that the field is too crowded for such students to arise above routine positions. This may lead



in turn to eliminative measures for students in those institutions when facilities are inadequate. As in the biological sciences, advanced chemistry courses will always attract a small number of men preparing for medicine.



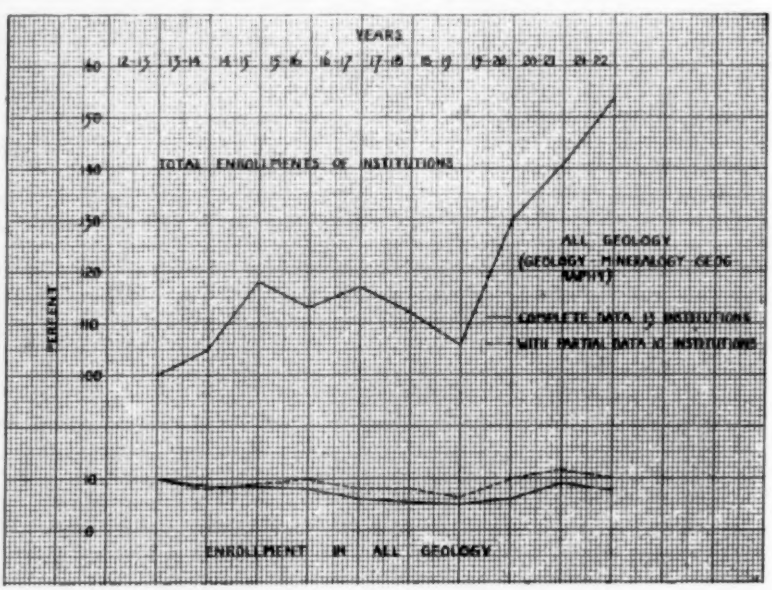
General Chemistry.

Sixteen institutions submitted complete data for this subject while six more could give partial data. It was found that twelve had an increase in the enrollment in general chemistry, while ten had a decrease. Five of the women's colleges showed an increase and two a decrease. The greatest gains, in order, were found in the New England women's colleges and the New England men's colleges, while the western institutions showed a slight gain; the greatest loss is shown in the northern institutions, followed by the southern women's colleges. The accompanying graph shows that the total enrollment of the institutions considered, increased 57 per cent in the ten years, but all the data available for this subject indicates that the enrollment of General chemistry has fallen from 1 to 2 per cent in this period. This is possibly due to eliminative measures taken by those institutions having inadequate facilities to accommodate larger numbers. The peak of enrollment for this, the largest division of chemistry, is the same as stated for the subject as a whole. Graphs for both complete and partial data indicate a loss in enrollment for this subject.

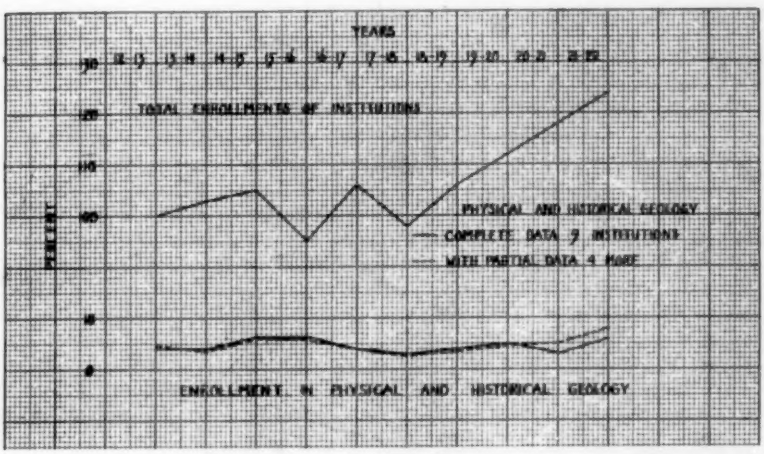
All Geology.

(Including geology, mineralogy, geography.)

Thirteen institutions submitted complete data; ten, partial data. Nine show an increase in enrollment and thirteen a de-



crease; one shows no change. Four of the women's colleges show an increase in enrollment and three a decrease. The only increase is found in the New England women's colleges; the greatest loss is in the northern institutions and the New England men's institutions. Less decrease was found in the west and south. The graph indicates that the total enrollment of the institutions has risen 54 per cent by the end of 1921-22 over 1912-13, while the complete data indicates that the enrollment had lost at least 2½ per cent in the later years. When the partial data is included, it is found that there have been slight increases in certain years but no appreciable gain at the end of the period studied. Any increase is possibly connected with the introduction of the data on geography; which at present seems to be a rising subject in college curricula and one which might well be normally stimulated by conditions arising during and since the war.



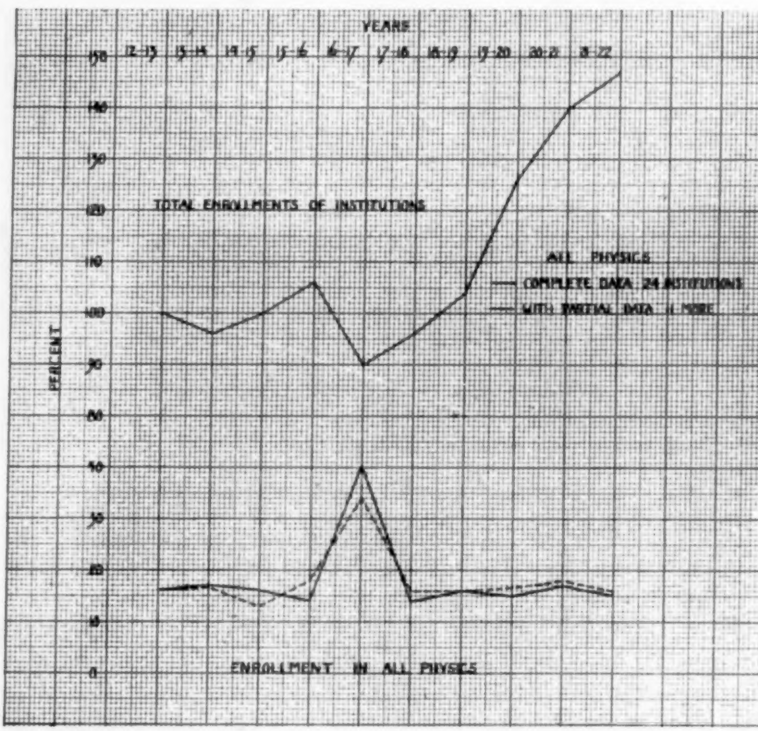
Physical and Historical Geology.

Thirteen institutions submitted data, complete information having been received from nine. Nine of these institutions show a decrease among which are two women's colleges; one woman's college shows no gain, four show an increase. The greatest increase is found in the New England women's colleges and next in the western institutions; while the greatest loss is found in the New England men's colleges and the northern institutions. The graph indicates that the total enrollment has risen during this period 25 per cent. The increases, however, seem to have more than offset the decreases, for by 1921-22, the enrollment in

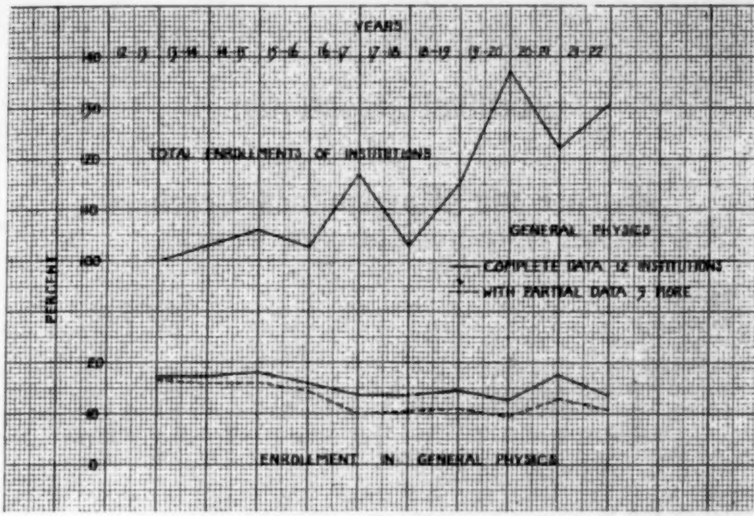
physical and historical geology seems to have gained from 2 to 4 per cent, the curve for the subject showing rather uniform fluctuations. Interest in the subject seems to be fully as high now as during the war. Some teachers of this subject believe that it has had little opportunity to exert its attractive power for students, because under the older system of majors and minors at various institutions it was accessible for relatively few students. As this branch is fundamental to most of the other geological sciences, this condition might ultimately affect the number of students taking advanced courses in this department.

Physics—All Branches.

Twenty-four institutions furnished complete data and eleven partial data, for this study. Seventeen show a decrease in enrollment, sixteen an increase, and two no change. Eight women's colleges show an increase, two a decrease and two no change.



The greatest increase is found in the New England women's colleges, followed by the southern institutions, while the greatest decrease is found in western institutions, followed by the north-



ern and men's colleges. While over the ten years, the total enrollments of the institutions increased 42 per cent, complete data of the twenty-five institutions shows that in all divisions of physics, there has been a decrease of 1½ per cent. If the partial data be included, physics has remained stationary.

The peak is attained during the year 1916-17, when, as may be imagined, interest in wireless, submarines and war contrivances, was at its height. It will be observed that except for this one year, physics has continuously included a fairly definite part of the enrollment in colleges and universities.

General Physics.

Twelve institutions furnished complete data for the subject of general physics; nine, only partial data. Thirteen of these institutions show an increase, seven a decrease, and one no change. Five of the women's colleges show increases in the enrollment in general physics while one shows a decrease. The greatest increase has been in southern institutions followed by New England women's colleges and northern institutions. The greatest loss is in New England men's institutions, followed by the western ones.

The one graph indicates that the total enrollments of the institutions considered by 1922 has increased by 31 per cent but that the subject of general physics in them has decreased from 3 to 5 per cent for the period showing a distiactly downward trend. In 1920-21, however, the peak enrollment of 18 per cent was attained. Study of the graph seems to bring out that interest in advanced courses of physics was unusually great during our period of the war.

(To be continued.)

Central Association of Science and Mathematics Teachers

CRANE JUNIOR COLLEGE, CHICAGO,

NOVEMBER 26 and 27, 1926

The Association is especially fortunate this year in being able to take advantage of an open-round trip rate of one and one-third fare in the Western Passenger Association territory and one and one-half fare in the Central Passenger Association territory. The former includes states west and north of Chicago and the latter east. Tickets will be on sale at points west of the Missouri River on the 23d and 24th and at points east of the Missouri on the 25th. This will make possible reduced rates for all members without the necessity of securing certificates.

For those who wish satisfactory hotel accommodations at low rates the Y. M. C. A. Hotel, 822 S. Wabash Avenue and the Y. W. C. A. Hotel at 830 S. Michigan Avenue are available. At the former rooms are 80 cents and $1.00 per day and at the latter from $.75 to $2.50. Reservations should be made at these hotels in advance.

To reach Crane Junior College take any of the following lines of transportation: Any Jackson Blvd. bus (except 36) to the door; Van Buren Street cars to the door; Elevated (Metropolitan, Garfield Park Branch) to Western Avenue and walk one half block north and one block east.

PROGRAM.

GENERAL SESSION.

Friday, Nov. 26, 9:30 a. m.

Bartolf Hall, Crane Junior College.

Address of Welcome, Willis E. Tower; response, E. R. Breslich; preliminary report of resolutions committee, Elliot R. Downing; address, Dr. Geo. F. Kay, Dean of College of Liberal Arts and State Geologist of Iowa, subject, "The Place of Man in the Universe"; address, President Max Mason, of the University of Chicago, subject, "Science and the Technique of Living."

Friday, 4 p. m.

Exhibits of books and apparatus in Rooms 164 and 165, Crane College.

Friday, 5 p. m.

Reception for members and their friends in the gymnasium, Crane College.

Friday, 6:30 p. m.

Dinner, place to be announced.

Friday, 8:00 p. m.

Address, Professor H. H. Newman, of the University of Chicago, subject, "What Should Be the Attitude of the High School Teacher Toward the Teaching of Evolution in the Schools?" This will be followed by general discussion.

Saturday, Nov. 27, 9:00 a. m.

Business meeting of the Association.

Saturday, 10:00 a. m.—All-Science Meeting.

Address, Professor R. H. Whitbeck, of the University of Wisconsin, subject, "The Evolution of Modern Geography"; address (illustrated), Mr. C. T. Scrage, Engineer of the American Telephone and Telegraph Company, subject, "Transmission of Pictures over Telephone Wires." address, Mr. A. H. Carver, Industrial Relations Department, Swift & Co., subject, "Industry's Estimate of the Value of Training in the Sciences to Its New Recruits."

Saturday, 12:30 p. m.

Meeting of Executive Committee.

Saturday, 1:30 p. m.

Excursions: a conducted tour of the International Stock Show, a visit to the plant of the American Telephone and Telegraph Company, where members may see the transmission of pictures actually in operation. Other excursions may be arranged.

Section Meetings, Friday, Nov. 26, 1:30 p. m.

Biology Section.

Chas. M. MacConnell, Chairman.

1:30-1:50—"Queer Plants and Animals that Men Eat," Clarence L. Holtzman, Assistant Principal, Waller High School; Past President of the Association.

1:50-2:30—"Ways and Means of Vitalizing the Biological Sciences," Dr. Franklin D. Barker, Professor of Zoology, Northwestern University, Evanston, Ill.; formerly, Professor of Zoology, University of Nebraska.

2:30-3:10—"The Relation of Laboratory Work to High-School Biology," Dr. M. M. Wells, President, General Biological Supply House, Chicago, Ill.

3:10-4:00—"Glacier National Park, A Naturalist's Outdoor Laboratory" (illustrated), Dr. Warren G. Waterman, Associate Professor of Botany, Northwestern University, Evanston, Ill.

Chemistry Section.

C. C. Whitman, Chairman.

Talk on Slide Rule, Miss Zena Brown, Kueffel & Esser Co.; "Background of the Study of Valence," G. T. Franklin, Lane Technical High School; discussion led by Mr. Davis, Lane Technical High School; "Effectiveness of Laboratory Work in Chemistry," Herbert R. Smith, Lake View High School; discussion led by Raymond W. Osborne, Francis Parker High School; "Discovery of the Element, Illinium," Dr. L. F. Yutema, University of Illinois.

General Science Section.

W. H. Atwood, Chairman.

"Who's Who in General Science," Chas. J. Pieper, University High School, Chicago; "Report on Vocabulary Studies," S. R. Powers, Teachers College, Columbia University; "Laboratory Work vs. Demonstration in the Teaching of Science," Elliot R. Downing, The University of Chicago; "Resourcefulness, an Unmeasured Ability," Hanor A. Webb, Peabody College for Teachers, Nashville, Tenn.

Geography Section.

Jas. H. Smith, Chairman.

"Some Definite Ways to Use Illustrative Material in the Teaching of Geography," Wm. P. Holt, State Normal College, Bowling Green, Ohio; "Presentation of Contour Mapping—an Exhibit," Viva Dutton Martin, Arsenal Technical High School, Indianapolis, Ind.; "The Kind and Amount of Geography That Should Be Included in the High School Curriculum," Thos. H. Finley, Austin High School, Chicago; "Geography in the Education of American Youth," Ray H. Whitbeck, University of Wisconsin.

Mathematics Section.

Everett W. Owen, Chairman

"The Writing and Choosing of Mathematical Textbooks," Prof. R. D. Carmichael, University of Illinois; "The National Council of Mathematics Teachers," C. M. Austin, Oak Park and River Forest Township High School, Oak Park, Ill.; "Evaluating Materials Adjusted to Varying Abilities When Used with a Group of Unclassified Pupils," Raleigh Schorling, University High School, Ann Arbor, Mich.; discussion, Alfred Davis, Soldan High School, St. Louis, Mo.; "Impressions From My Study of Mathematics," Chaloner McNair, Yale '26, Oak Park, Ill., F. N. Whaley, Northwestern University '29, Evanston, Ill., Fred Slaughter, Oak Park High School, '27, Oak Park, Ill.

Physics Section.

E. Howard Struble, Chairman.

The program of this section has not been received but will be published in the regular printed program. Write Frank E. Goodell, President West High School, Des Moines, Iowa, or Ada L. Wechel, Secretary, High School, Oak Park, Ill., for further particulars. Complete printed programs will be mailed to members about Nov. 1st.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

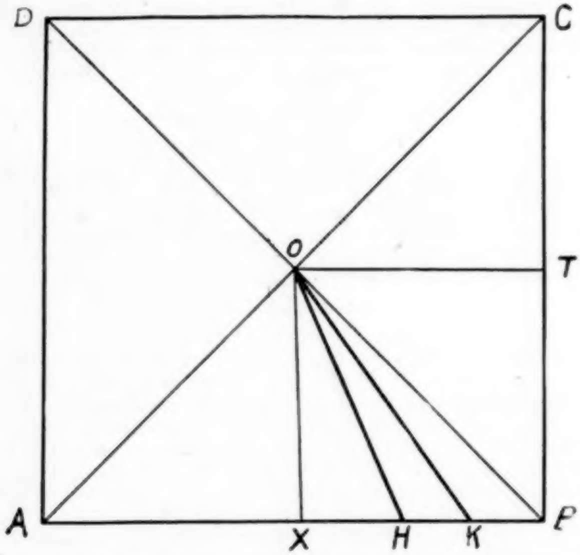
The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

SOLUTION OF PROBLEMS.

926. *Proposed by the Editor.*

How many acres does a square tract of land contain which sells for $80 per acre and which is paid for by the number of silver dollars that will lie upon its boundary? (Taken from "Arithmetic for the Eighth Year" by David Felmley).

I. *Solved by J. H. Glaeser, Trenton, Ill.*



Let the square ABCD represent the square tract of land which is to be paid for by the number of silver dollars which may be placed on its boundary. Represent one acre in the form of a triangle OHK with vertex at O and altitude OX.

Since each acre in the form a triangle sells for $80, the base of each triangle is 120 inches, or 10 ft. Since each acre contains 43,560 sq. ft., the altitude OX equals 8,712 ft. Hence the side of the square is 17,424 ft., and the required area is 6,969.6 acres.

II. *Solved by I. N. Warner, Platteville, Wis.*

Let the square farm be represented by a geometric square ABCD. Assume all the silver dollars removed from three sides of the field and stacked upon those of the side AB. Then on a ten-foot length of AB would be stacked $320, or enough to pay for 4 acres. Now divide the square field into rectangles, each 10 feet in width, and of sufficient length to contain 4 acres. This, of course, is 17,424 ft. in length, which gives 6,969.6 acres as the area.

III. *Solved by Michael Goldberg, Washington, D. C.*

If the side of the square is s feet, and the diameter of the silver dollar is d feet, the cost gives the following equation;

$$\text{Cost (in dollars)} = \frac{80s^2}{43{,}560} = \frac{4s}{d}.$$

Hence $s = (43{,}560)/(20d)$, and the acreage is denoted by $(108.9)/d^3$.

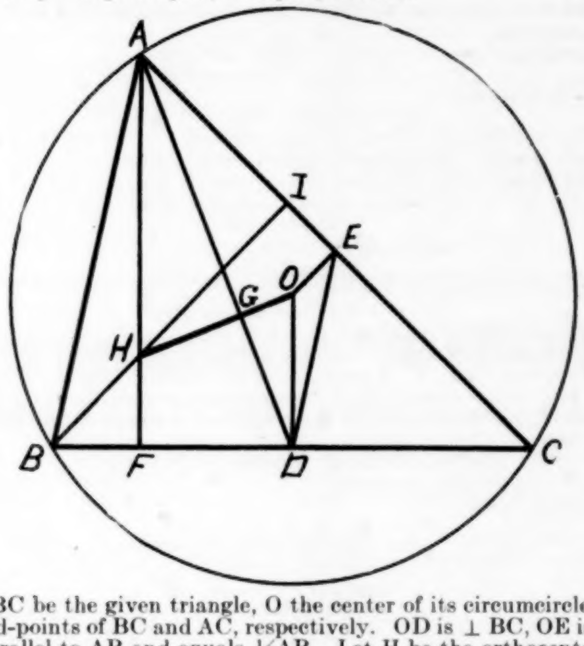
Also solved by *George Sergent, Tampico, Mexico; S. D. Turner, Cambridge, Mass.; John Rowe, Redlands, Cal.; Raymond Huck, Shawneetown, Ill.*

927. *Selected.*

Prove that the following points are collinear: the circumcenter of the triangle, the point of intersection of the medians, the point of intersection of the altitudes of the triangle.

Editor: This line is called the *Euler line of a triangle.*

I. *Solved by George Sergent, Tampico, Mexico.*



Let ABC be the given triangle, O the center of its circumcircle, D and E the mid-points of BC and AC, respectively. OD is $\perp$ BC, OE is $\perp$ AC, DE is parallel to AB and equals ½AB. Let H be the orthocenter of the altitudes of the triangle. The triangles ODE and BHA are similar, and since DE = ½AB, we have OD = ½AH. The line OH intersects the median AD in G. The triangles DGO and AGH are similar. Since OD = ½AH, we have GD = ½GA. G is therefore the point of intersection of the medians. This proves the proposition.

II. *Solved by Raymond Huck, Shawneetown, Ill.*

Let the triangle with vertices $(-b, O)$, (a, O) and (O, h) be represented with the base on X-axis, and altitude on Y-axis. The circumcenter is the point E $\left[\frac{a-b}{2}, \frac{h^2-ab}{2h}\right]$. The medians intersect at E′ $\left[\frac{a-b}{3}, \frac{h}{3}\right]$. The altitudes intersect at H$\left(O, \frac{ab}{h}\right)$. The equation of the line through EE′ is

$x(h^2-3ab) - y(ab-bh) + a^2b - ab^2 = O$. Since the coordinates of H satisfies the above equation, proves that the points E, E′ and H are collinear.

III. *Solved by W. W. Horner, Donora, Pa.,* and *Charles T. Oergel, State College, Pa.*

Each of the solvers used the method of *Solution II* to determine the three points in question, but proved the three points were collinear by the vanishing of the determinant formed from the coordinates of the three points.

Also solved by *Michael Goldberg, Washington, D. C.; S. D. Turner, Cambridge, Mass.*, using properties of the nine-point circle; *W. W. Horner, Donora, Pa.*, a second solution; *Leonard Carlitz, Philadelphia, Pa.*

928. *Proposed by J. F. Howard, San Antonio, Texas.*

Find integers which satisfy the following condition:

$$a^2+b^2+c^2 = ab+ac+bc$$

I. *Solved by S. D. Turner, Cambridge, Mass.*

From $a^2+b^2+c^2 = ab+ac+bc$, we get the quadratic in a

$$a^2-(b+c)a+(b^2+c^2-bc)=0.$$

Solving the equation for a gives

$$a=\frac{(b+c)\pm(b-c)\sqrt{-3}}{2}.$$

If a be real, then the imaginary part must vanish, in which case $b=c$. Hence $a=b=c$.

II. *Solved by Leonard Carlitz, Philadelphia, Pa.*

$$a^2+b^2+c^2=ab+ac+bc$$

may be arranged as

$$(a-b)^2+(a-c)^2+(b-c)^2=0.$$

Hence $(a-b)=0$, $(a-c)=0$, and $(b-c)=0$.

Therefore $a=b=c$ satisfies the condition as stated.

III. *Solved by George Sergent, Tampico, Mex.*

Since $(a-b)^2=a^2+b^2-2ab$,

$a^2+b^2>2ab.$

Similarly, $a^2+c^2>2ac$,

$b^2+c^2>2bc.$

Adding, and dividing by 2, gives

$$a^2+b^2+c^2 > ab+ac+bc. \qquad (2)$$

Hence to satisfy the condition (1), $a=b=c$.

Also solved by *Michael Goldberg, Washington, D. C.*

929. *Proposed by I. N. Warner, State Normal, Platteville, Wis.*

Find two numbers such that their product is equal to the difference of their squares, and the sum of their squares is equal to the difference of their cubes.

I. *Solved by Michael Goldberg, Washington, D. C.*

Let a and b be the numbers.

Let $a=rb$, then

$$rb^2=r^2b^2-b^2, \text{ or } r^2-r-1=0.$$

The value of $r=\frac{1}{2}(1\pm\sqrt{5})$.

Also

$$r^2b^2+b^2=r^3b^3-b^3, \text{ or}$$
$$b^2(r^2+1)=b^3(r^3-1).$$

$$\text{Hence } b=\frac{r^2+1}{r^3-1}=\frac{5\pm\sqrt{5}}{2(1\pm\sqrt{5})}=\tfrac{1}{2}\sqrt{5},$$

and $a=rb=\frac{1}{4}(5\pm\sqrt{5})$.

II. *Solved by George H. Gatje, Islip, L. I., N. Y.*

Let x and y be the numbers, then

$$xy=x^2-y^2 \ (1), \quad \text{and } x^2+y^2=x^3-y^3 \ (2).$$

Solving equation (1) for x we get $x=\dfrac{y\pm y\sqrt{5}}{2}$. Substituting in (2) gives a cubic in y which has one root $y=\frac{1}{2}\sqrt{5}$. Hence $x=\frac{1}{4}(5\pm\sqrt{5})$.

Also solved by *S. D. Turner, Cambridge, Mass.; George Sergent, Tampico, Mex.; T. E. N. Eaton, Redlands, Cal.; James A. Gardiner, Wilmington, Del.* One incorrect solution was received.

930. *For High School Pupils. Suggested in Solution II of Problem 898, appearing in the February issue.*

ABCD is an inscribed quadrilateral. Prove

$$\frac{DC}{AB}=\frac{AD\cdot BD+AC\cdot BC}{AC\cdot AD+BC\cdot BD}.$$

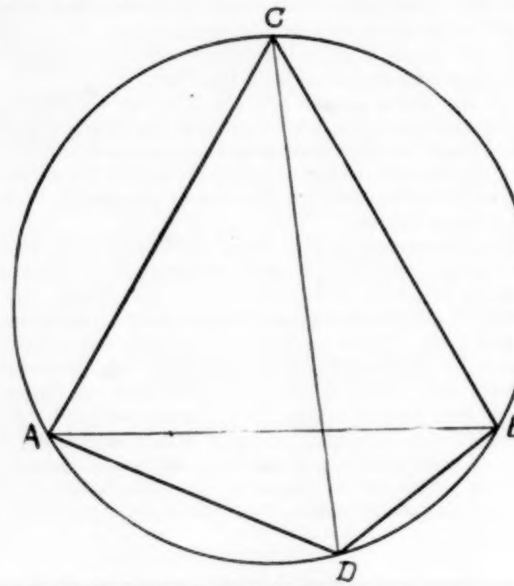
NEW TEXAS POTASH MAY SOLVE FERTILIZER PROBLEMS.

The potash fields recently discovered in Texas are now believed comparable with the famous German ones which before the war supplied the world with potash. Dr. John W. Turrentine, in charge of potash investigation in the U. S. Bureau of Soils, at the meeting of the American Chemical Society recently, said that there was ground for hope that a potash industry of national importance may be developed here. Incomplete data so far available fail to reveal a workable deposit, Dr. Turrentine said, but amply justify the thorough exploration of this field.

The isolation of the Texas potash fields is a severe drawback to their commercial development, but it can be overcome, Dr. Turrentine believes, by a system of pipe-lines for the transportation of the concentrated brines from the mines to the nearest seaports. At these places the solution could be chemically refined and shipped by water routes to markets of the southern and middle western states.

The potash salts discovered in the Texas fields could be used for fertilizer without refining, but the low concentration, it is believed, would prohibit its transportation by rail to any great distances. However it might be used without refining in the southwest where no supplies of cheap potash are now available. These salts could be easily converted into rich potash compounds by simple chemical treatment which would reduce transportation costs and enable them to compete with the cheap Franco-German potash on the market today, Dr. Turrentine said. Potash recovery, which was formerly a mining industry, is now essentially chemical, through the need of making the final product richer and thereby cutting transportation costs. The Texas potash industry, he believes, will be no exception, and its success will depend on the ingenuity of the chemist. —*Science Service.*

Editor: The relation expressed in *Problem 930* holds only for the conditions of *Problem 898*, which states that *the triangle* ABC *is equilateral, and the point D is on the minor arc* AB. The following solution is submitted.



Denote angle DAC by P, and angle ADB by Q.

$$\text{Area of } \frac{\triangle ADB = (\tfrac{1}{2})\ AD\cdot BD \sin Q.}{\triangle ABC = (\tfrac{1}{2})\ AC\cdot BC \sin Q.} \qquad (1)$$

$$\frac{\triangle ACD = (\tfrac{1}{2})\ AC\cdot AD \sin P.}{\triangle BCD = (\tfrac{1}{2})\ BC\cdot BD \sin P.} \qquad (2)$$

Adding left members and right members, respectively, of the above relations, and dividing corresponding members, gives

$$\frac{(\tfrac{1}{2})\sin Q[AD\cdot BD + AC\cdot BC]}{(\tfrac{1}{2})\sin P[AC\cdot AD + BC\cdot BD]} = 1. \qquad (3)$$

Since $\sin Q : \sin P = AB : CD$ (3) reduces to

$$\frac{AD\cdot BD + AC\cdot BC}{AC\cdot AD + BC\cdot BD} = \frac{DC}{AB}.$$

The *Editor* calls attention to the following error: page 192, February issue, 1926, tenth line from bottom of the page, which should read

$$DC\cdot AB = DB\cdot AC + DA\cdot BC.$$

PROBLEMS FOR SOLUTION.

941. *Proposed by J. S. Georges, University School, Chicago.*

The ceiling of a church is in the form of a surface consisting of two circular half cylinders with equal radii a, with lengths l and m respectively, intersecting each other at right angles, and with their elements intersecting the walls at right angles. It is required to find the total volume of the church if the distance from the floor to the highest point of the ceiling is k.

942. *Proposed by Virginia Seidensticker, Hyde Park, Chicago.*

Construct a triangle given the angle A, side a, and the bisector of angle C.

943. *Proposed by Leonard Carlitz, Philadelphia, Pa.*

Find the value of the infinite product

$$\frac{2}{\sqrt{2}}\cdot\frac{2}{\sqrt{2+\sqrt{2}}}\cdot\frac{2}{\sqrt{2+\sqrt{2+\sqrt{2}}}}\cdot\cdot\cdot\cdot \text{ to infinity.}$$

944. *Proposed by George Sergent, Tampico, Mexico.*
From a point V within a triangle ABC, perpendiculars VX, VY, VZ, are drawn to the sides *a*, *b*, *c*, respectively. Determine V so that XZ equals a given length, *m*, and YZ a given length, *n*.

945. *For High School Pupils. Proposed by J. F. Howard, San Antonio, Texas.*
The lines joining the vertices of a triangle to the points of contact of the inscribed circle are concurrent.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones

The White Motor Company, Cleveland, Ohio.

To Readers of School Science and Mathematics:
You are invited to propose questions for solution or discussion.
You are asked to answer questions.
Examination papers are always desired. Send in your own papers or any others. Some are interested in college entrance examinations, others in school or college examinations. All are desired.
Please address all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E., Cleveland, Ohio.

QUESTIONS AND EXAMINATION PAPERS.

480. Proposed by J. C. Packard, Brookline, Mass.
Does it require more or less work on the part of the hoisting engine to carry a man up a moving stairway when he is walking up the stairs while the treads are moving, than when he is standing still?

481. How much difference exists between the teaching of chemistry today and twenty years ago?
a. Subject matter;
b. Laboratory work;
c. Method of conducting classes;
d. Demonstrations;
e. Examinations and examination questions;
f. Applicability to daily life;
g. Distinct improvements;
h. Retrogressions—If worse, specify exactly how and where;

The above questions offer opportunity for the readers of this department and for all who are deeply interested in the improvement of science teaching in general to express either their satisfaction or dissatisfaction with present conditions.

Complete Answers Are Not Expected.

Send in your ideas on any one or more of the separate questions. Please be prompt. Do it now!

COLLEGE BOARD EXAMINATIONS—CHEMISTRY—1906-1926.
A comparison of the papers that follow will give some food for thought. Answer the questions asked above.

CHEMISTRY—1906.

Friday, June 22, 1906, 3:45–5:45 P. M.

Answer seven questions as indicated below.

In this examination 30 counts will be based on the laboratory note book submitted by the candidate, and 70 counts on the following questions.

A

Answer both questions in this group.

1. Ice melts upon the application of heat, while wood chars. Explain briefly why one of these changes is regarded as chemical and one as physical. State and illustrate the law of definite proportions. Define briefly the terms (a) reduction, (b) neutralization. Give an illustration of each. Give at least two reasons for the belief that the oxygen and nitrogen of the atmosphere are not in chemical combination.

2. Complete three of the following equations, using formulas:
iron + sulphuric acid =
zinc oxide + nitric acid =
calcium hydroxide + carbon dioxide =

marsh gas + oxygen (ignited) =
hydrogen sulphide + lead nitrate =

Classify the compounds given below into (a) acids, (b) bases, (c) salts, (d) anhydrides: SO_3, $NaNO_3$, HBr, $Ba(OH)_2$, $CaSO_4$, P_2O_5, H_3BO_3, NH_4OH, H_3PO_4, CO_2.

B

Answer only two questions from this group.

3. State, from personal experience, how carbon dioxide was prepared in the laboratory, and write the reaction involved. State two properties of carbon dioxide which were ascertained by experiment, and describe these experiments briefly. How may it be shown that carbon dioxide is one of the products of respiration?

4. How may chlorine and hydrochloric acid gas be obtained, starting from common salt in each case? In what chemical way may these two substances be distinguished from each other? What is the nature of the bleaching action of chlorine? Give reasons why the halogens are regarded as members of a natural group of elements.

5. How may hydrogen sulphide be prepared? State three of its properties. What products are formed when a jet of hydrogen sulphide burns in air? Give two characteristic properties of concentrated sulphuric acid, and two important uses to which this acid is put. Explain its action upon wood.

C

Answer only two questions from this group.

6. What is the nature of the most important chemical change which occurs during the production of pig iron from its ores in the blast furnace? How does a steel differ chemically from a pig iron? Give the names of two processes for the production of steel from cast iron. Define the terms ore and flux. Give the chemical name and formula of two important compounds of iron.

7. Name two compounds of sodium which are commonly employed in the household, and give the uses of each. What are the constituents of common gunpowder? What is the formula of caustic potash? What is a commercial source of ammonia? How may its great solubility in water be demonstrated?

8. What do you consider the most important compound of (a) nitrogen, (b) chlorine, (c) carbon? Give a reason for your selection in each case. How may water be freed from (a) insoluble solid matter, (b) dissolved salts, (c) dissolved air? Hydrogen is produced by the action of sulphuric acid upon metallic zinc. What other substances might be substituted for zinc? Explain clearly why nitric acid could not be substituted for sulphuric acid.

D

Answer only one question from this group.

9. What volume of oxygen, measured under standard conditions, will be evolved when 108 grams of mercuric oxide are decomposed by heating? What will be the volume of this oxygen at 770 mm. pressure and 27°C.? (Atomic weights: Hg = 200, O = 16. Weight of 1 liter of oxygen under standard conditions is 1.43 grams.)

10. What weight of ammonium chloride, when acted upon by calcium hydroxide, is required to produce 17 grams of ammonia gas, and what weight of calcium chloride is formed at the same time? (Atomic weights: N = 14, Cl = 35.5, Ca = 40.)

TWENTY YEARS AFTERWARD.
CHEMISTRY—1926.

Friday, June 25, 9 a. m. Two hours.

Answer ten questions as indicated below.

Number and letter your answers to correspond to the questions selected.

No credit will be given for problems on this paper unless the methods of calculation are clearly indicated. Final numerical answers need not be carried beyond one place of decimals.

PART I.

(Answer all questions in Part I.)

1. Write equations for the following reactions using formulas throughout. Equations must be properly balanced to receive credit. (a) slaked

lime and nitric acid. (b) aluminum chloride and sulphuric acid. (c) ammonium sulphate and sodium hydroxide. (d) carbon monoxide passed over heated ferric oxide.

2. Define and illustrate each of the following: catalyst, basic oxide, electrolysis, acid.

3. (a) What weight of HCl is required for complete reaction with five grams of $CaCO_3$? (b) What volume of CO_2, at standard conditions, would be produced in the foregoing reaction? (atomic weights: Ca 40, Cl. 35.5, O 16, C 12, H 1. 22.4 liters of carbon dioxide, at 0° C. and 760 mm., weigh approximately 44 grams.)

4. Describe the preparation of two of the following substances, using labeled diagrams of the apparatus and giving equations for the reactions involved: hydrogen sulphide, chlorine, ammonia.

5. Name the law or theory suggested by each of the following statements: (a) nitrogen forms the oxides NO and NO_2; (b) the invention of a perpetual-motion machine seems an impossibility; (c) doubling the absolute temperature of a gas doubles its volume if the pressure remains constant; (d) when 216 grams of any sample of pure mercuric oxide are decomposed, 200 grams of mercury and 16 grams of oxygen are formed.

6. Give one property of each of the following substances which determines some important use of that substance and explain in each case how that property makes it useful: potassium nitrate, carbon, calcium, carbonate, helium.

PART II.

(Answers four questions from Part II. Answers to extra questions will receive no credit.)

7. How would you identify each of the following ions: sulphate, chloride, ferric, lead?

8. Mark the following statements true or false giving a reason for your answer in each case: (a) Ethyl alcohol (C_2H_5OH) will not turn litmus blue. (b) Limestone never dissolves appreciably in rain water. (c) Those compounds containing the elements carbon, hydrogen, and oxygen are called hydrocarbons. (d) The carbon in plants is taken directly from the soil.

9. A certain solution contains 40 grams per liter of sodium hydroxide. How many cubic centimeters of this solution would be required to neutralize 200 cc. of a solution of sulphuric acid which contains 49 grams per liter? (Atomic weights: S 32, Na 23, O 16, H 1.)

10. Indicate which of the following reactions go to completion and which do not. Give a reason for your answers in each case. (a) Silver nitrate and sodium chloride. (b) Sodium hydroxide and sulphuric acid. (c) Sodium sulphate and hydrochloric acid. (d) Sodium nitrate and hydrogen sulphide.

11. Give an example of a substance suggested in each case by the property mentioned below. State one household or industrial use for each of these substances. (a) An acid having a high boiling point. (b) A metal having a high melting point. (c) A metal that does not combine directly with oxygen. (d) A gas that is easily liquified.

12. Give the names of two distinct types of furnaces used in obtaining metals from their ores, or in purifying metals. What two different means are employed in metallurgical operations to obtain very high temperatures? Indicate by means of equations the chemical changes involved in the metallurgy of zinc.

Photoelectric cells, which give an electric current when exposed to light, have been made so delicate that they can detect the variation in light when a hair is placed in front of a nearby electric bulb.—*Science Service.*

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 35 cents a single copy. The Mathematical Supplements for 20 cents a copy. In sets, the prices are, postpaid:

School Mathematics and Supplements, Vol. I, five numbers	\$1.10
School Science, Vol. I, seven numbers	5.75
School Science, Vols. II, 7 numbers	5.00
School Science, Vol. III, eight numbers	5.50
School Science, Vol. IV, three numbers	.85
School Science and Mathematics, Vols. V, VI, VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI and XVII, each	2.75
School Science and Mathematics, Vols. XVIII, XIX, XX, XXI, XXII, XXIII and XXIV, each	2.75

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, June-July, *Menasha, Wis., $5.00 a year, 60 cents a copy.* A New Method for Determining a Series Solution of Linear Differential Equations with Constant or Variable Coefficients, W. O. Pennell, Southwestern Bell Telephone Co., St. Louis. A New Type of Freshman Course in Mathematics, N. J. Lennes, University of Montana. On Diophantine Relations, W. H. Rittenhouse, Philadelphia.

Condor, September-October, *Cooper Ornthiological Club, Berkeley, $3.00 a year, 50 cents a copy.* Examples of Recent American Bird Art, Harry Harris. How the Bird Census Solves Some Problems in Distribution, May Thacher Cooke. The Faunal Areas of Baja California del Norte. Griffing Bancroft. The California Forms of Agelaius phoeniceus (Linnaeus), A. J. van Rossem. Notes on the Birds of the Baboquivari Mountains, Arizona, Stephen C. Bruner.

Education, September, *The Palmer Co., Boston, $4.00 a year, 40 cents a copy.* The Obtrusive Ego, Mary Evelyn Shipman, University of Pittsburg. With Social and Individual Values of the School Analyzed in Terms of an Educational Balance Sheet, Carter V. Good, Professor of Education, Miami University. Junior High School Tendencies, Carl W. Schrader, State Board of Education, Boston. Some Higher Aims of the University, E. P. Conkle, The University of North Dakota. Training Rural Teachers in Rural Dramatics, A. R. Root, State Teachers College, Aberdeen, South Dakota. Education and the Moving-Picture Show, Harvey C. Lehman and Paul A. Witty, The University of Kansas. The Married Teacher, Supt. R. C. Clark, Seymour, Conn.

Journal of Chemical Education, August, *Rochester, N. Y., $2.00 a year, 35 cents a copy.* The Chemistry of Leather Manufacture, Henry B. Merrill, A. F. Gallun & Sons Co., Milwaukee. The Emerald Table of Hermes Trismegistus, Tenney L. Davis, Massachusetts Institute of Technology. Practical Chemistry for Beginners, H. A. J. Pieters, Zierikzee, Holland. Honor Students in Chemistry, Arthur A. Noyes and James E. Bell, California Institute of Technology. An Advanced Chemistry Course in a High School, Oscar R. Foster, Manual Training School, New York City. Illustrating the Black Art, R. D. Billinger, Lehigh University. Orientation of Students in Chemistry: Aptitude and Placement Tests and Results in First Year Chemistry, C. A. Brautlecht, University of Maine. An Application of Colloid Chemistry to Lubrication, Raymond Szymanowitz, Laboratory of G. W. Acheson, Caldwell, N. J. The Value of Tests in Writing Chemical Equations, Roland B. Hutchins, Lynn Classical High School, Lynn, Mass. A Determination of the Scientific Attitudes, Francis D. Curtis, University of Michigan. A Study of the Mathematics of Calorimetry by Means of a General Formula, Robert F. McCrackan, Medical College of Virginia. Potentiometric Titrations as a Means of Teaching Electrochemical Principles, N. Howell Furman, Princeton University.

Journal of Chemical Education, September. Growth of the Dyestuffs Industry, R. E. Rose, E. I. DuPont de Nemours & Co., Inc., Wilmington, Delaware. Some Phases of the Work of the Bureau of Chemistry on Dust Explosions in Industrial Plants, David J. Price, Bureau of Chemistry, Washington, D. C. Prize Essays, High School Students. The Influence of Early Science on Formative English, P. H. Hembdt, Albion College, Albion, Michigan. A New Periodic Table of the Elements, C. J. Monroe and W. D. Turner, Missouri School of Mines, Rolla, Missouri.

Journal of Geography, September, *2249 Calumet Avenue, Chicago, $2.50 a year, 35 cents a copy.* Twelve Hundred Selected Place Names, Douglas C. Ridgley, Clark University. An Isolated Industry: Pottery of North Carolina, Ivan Stowe Clark, University of North Carolina. The Dependence of the Social Sciences upon Geographic Principles, Ella Jeffries, State Teachers College, Bowling Green, Kentucky. A Study of United States Fisheries: A Sixth Grade Project, Georgiana Parnell, Barrows School, Springfield, Massachusetts.

Mathematical Gazette, G. Bell & Sons, London. January. Some New Theories in Geometry of Space, Prof. C. E. Weatherburn. Mathematics for Girls. A Lesson in Theoretical Arithmetic, C. Tweedie. March.

Some Problems of Atomic Structure, E. N. DaC. Andrade. Modern Theories of Integration, E. Carey Francis. May. Asymptotes, T. P. Nunn. How *e* is to be Introduced into Our Teaching, W. Miller, The Relative Abilities in Mathematics of Boys and Girls. July. A Problem in Four-Fold Geometry, D. B. Mair.

National Geographic Magazine, September, *Washington, D. C., $3.50 a year, 50 cents a copy.* Marching Through Georgia Sixty Years After, Ralph A. Graves. Flying Over Egypt, Sinai, and Palestine, P. R. C. Groves and J. R. McCrindle. Along the Banks of the Colorful Nile, Gervais Courtellemont. The First Flight to the North Pole, Richard Evelyn Byrd.

Popular Astronomy, August-September, *Northfield, Minn., $4.00 a year, 45 cents a copy.* Around the World for the Sumatra Eclipse of 1926, Harlan True Stetson. The Fireballs of November 15 and December 29, 1925, Willard J. Fisher. Naval Observatory Eclipse Expedition to Sumatra, F. B. Littell. Report on Mars, No. 37, William H. Pickering.

Science, September 17, *Grand Central Terminal, New York City, $6.00 a year, 15 cents a copy.* James Hutton, the Pioneer of Modern Geology, Professor Wm. H. Hobbs. Cooperative Research—the Plan of the National Tuberculosis Association, Dr. William Charles White.

Scientific American, September, *New York, $4.00 a year, 35 cents a copy.* American Building Methods in Greece, Gladys Thompson. Was the Cave Man a House-Builder? J. Reid Moir. A Twenty-five Foot "Eye," Henry Norris Russell. Uncle Sam, Spendthrift—IV, J. Bernard Walker. The Romance of the Norfolk Islanders, Dr. H. L. Shapiro. A Distinctly New Rectifier, H. H. Sheldon. Are We Over the Pole, Nell Ray Clarke. Plants Grow in Air-tight Containers, Raymond H. Wallace. What Lowered the Great Lakes, J. Bernard Walker.

Scientific Monthly, September, *The Science Press, New York, $5.00 a year, 50 cents a copy.* Religion and Man's Origin, Dr. C. G. Abbot. The Bible and Science, Dr. George S. Duncan. The Protection of National Culture as the Proper Basis of Immigration Restriction, Jerome Dowd. Some Aspects of Northwest Coast Indian Art, Herbert W. Krieger. Francesco Redi, the Father of Experimental Entomology, Harry B. Weiss, Ariadne, or Science and Kindliness, Professor R. D. Carmichael. Race and Psychology, Professor Thomas R. Garth. Laboratory Methods of Analyzing Spectra, With Applications to Atomic Structure, Dr. Arthur S. King.

School Review, September, *University of Chicago Press, $2.50 a year, 30 cents a copy.* Subject Combinations in High School Teachers' Programs, Thomas J. Kirby. Junior-College Aims and Curriculums, A Monroe Stowe. Provisions for Meeting Individual Differences Among Pupils in the Junior High School, C. O. Davis. The Test-Study Method versus the Study-Test Method in Teaching Spelling, L. R. Kilzer. Directed Study, C. C. Hillis and J. R. Shannon.

BOOKS RECEIVED.

New Second Course In Algebra, Brief Edition, by Herbert E. Hawkes, Professor of Mathematics in Columbia University, William A. Luby, Head of the department of Mathematics in the Junior College of Kansas City, and Frank C. Touton, Professor of Education in the University of Southern California. Cloth. Pages ix+333. 12x18 cm. 1926. Ginn & Co. Price $1.28.

Arithmetic Work Book, Grade Three, by F. B. Knight, G. M. Ruch and J. W. Studebaker, Edited by G. W. Myers. Paper. Pages v+74. 20x28 cm. 1926. Scott, Foresman and Company, Chicago. Pupils' Edition, 36 cents, Teachers' Edition, 48 cents.

A Laboratory Manual for Elementary Zoology, by Libbie Henrietta Hyman. The University of Chicago. Cloth. Pages xviii+182. 16x25 cm. 1926. The University of Chicago Press. Price $2.50.

Mathematical and Physical Papers 1903-1913, by Benjamin Osgood Peirce, Late Hollis Professor of Mathematics and Natural Philosophy in Harvard University. Cloth. Pages viii+444. 15x23 1-2 cm. 1926. Harvard University Press. Price $5.00

Plane Trigonometry and Logarithms, by B. H. Brown, Assistant Professor of Mathematics, Dartmouth College and edited by J. W. Young, Professor of Mathematics, Dartmouth College. Cloth. Pages 66. 13x18 cm. 1925. Houghton Mifflin Company.

Modern Plane Geometry, Graded Course, by Webster Wells and Walter W. Hart, Associate Professor of Mathematics, School of Education, University of Wisconsin. Cloth. Pages x+322. 13x18 1-2 cm. 1926. D. C. Heath & Co.

Elementary Accounting, Part II, by Hiram T. Scovill, Professor and Head of Department of Accountancy and Henry Heaton Baily, Assistant Professor of Accountancy, University of Illinois. Cloth. Pages x+457. 15x22 cm. 1926. D. C. Heath and Company.

Pupil Adjustment in Junior and Senior High Schools, by William Claude Reavis, Assistant Professor of Secondary Education and Principal of the University High School, University of Chicago. Cloth. Pages xviii+348. 12x19 cm. 1926. D. C. Heath and Company.

Modern Biology: Its Human Aspects, by Harry Dwight Waggoner, Professor of Biology, Western Illinois State Teachers College. Cloth. Pages vii+482. 13x20 cm. 1926. D. C. Heath and Company.

Harmonic Curves, by William F. Rigge, The Creighton University, Omaha, Nebraska. Cloth. Pages 213. 16x24 cm. 1926. Loyola University Press. Price $3.25.

Elements of Agriculture, by G. F. Warren, Professor of Agricultural Economics and Farm Management, New York State College of Agriculture, at Cornell University. Cloth. Pages xx+549. 13x19 1-2 cm. 1926. The Macmillan Co.

General Physics for the Laboratory, by Lloyd W. Taylor, Professor of Physics, Oberlin College, William W. Watson, Instructor in Physics, the University of Chicago, and Carl E. Howe, Assistant Professor of Physics, Oberlin College. Cloth. Pages vi+247. 15x23 cm. 1926. Ginn & Co. Price $2.40.

Mental Tests: Their History, Principles and Applications, by Frank N. Freeman, Ph. D., Professor of Educational Psychology, The University of Chicago. Cloth. Pages ix+503. 12 1-2x18 1-2 cm. 1926. Houghton Mifflin Company. Price $2.40.

New Physical Geography by Ralph S. Tarr, B. S., Late Professor of Dynamic Geology and Physical Geography in Cornell University, and O. D. von Engeln, Ph. D., Professor of Physical Geography in Cornell University. Cloth. Pages xi+689 15x23 cm. 1926. The Macmillan Company.

BOOK REVIEWS.

Plane Trigonometry and Logarithms, by B. H. Brown, Assistant Professor of Mathematics, Dartmouth College. pp. 66. 13x19 cm. 1925. Boston. Houghton Mifflin Company.

This little volume has been written to meet the needs of certain classes of engineering students and others who need merely the essentials of trigonometry. It will no doubt appeal to many students in the secondary schools who wish a course in trigonometry of college level.

J. M. Kinney.

New Second Course in Algebra, by Herbert E. Hawkes, Professor of Mathematics in Columbia University, William A. Luby, Head of the Department of Mathematics in the Junior College of Kansas City, and Frank C. Touton, Professor of Education in the University of Southern California. pp. 333. 13.5x19 cm. 1926. Boston: Ginn and Company.

This New Second Course is a revision of the Revised Second Course. It is being brought out in two editions, a brief edition for a half year's course beyond the work usually done in the first high school year, and an enlarged edition intended for a full second year.

The exercises and problems are new and have been carefully graded. Somewhat more emphasis has been placed upon the explicit application of the formula than appeared in the earlier editions.

J. M. Kinney.

The History of Arithmetic, by Louis Charles Karpinski, Professor of Mathematics, University of Michigan. pp. 200. 14x19.5 cm. 1925. Chicago: Rand McNally and Company.

The development of arithmetic from the remote past to the present time is unfolded in this volume. We find discussions of the arithmetics of the Egyptians, Babylonians, Greeks, Aztecs, Hindus, Romans, Arabs, and of the peoples of medieval and modern times together with a large number of illustrations. In fact the story of the development could be read to a large extent from these illustrations.

Prof. Karpinski points out that the modern tendency in arithmetic is to provide contact with life at as many points as possible. In the History of Arithmetic he shows that arithmetic connects intimately with the early civilization of America and the Orient. A knowledge of this connection is of great value to the teacher of arithmetic since it enables him to pick out the essential. J. M. Kinney.

Exercises and Tests in Algebra, by David Eugene Smith, William David Reeve, and Edward Longworth Morss. pp. 224. 20x24.5 cm. Paper cover. 1926. $.72. Boston: Ginn and Company.

These exercises and tests, 224 in number, are designed to furnish material that can be used for drills and tests to accompany any modern elementary algebra.

The authors state that they have been guided in the selection of material by the following principles:

(1) There can be no skill without drill.

(2) The parts of algebra that are useful in science or in practical work are relatively simple.

(3) To be successful as teaching devices, tests must be restricted to topics which have been studied by the students.

(4) Tests should measure specific strengths and should reveal specific weaknesses.

(5) A mastery of the essential parts of algebra depends to a large extent upon the power acquired in simple operations and solutions. For this reason considerable emphasis is placed upon rapid work in the solution of easy formulas and equations.

(6) Tests should provide an index of the success of the teacher in instruction. Students' failures may be due to lack of ability, to not using the abilities which they have, to unsatisfactory teaching, or to the use of too difficult material in the content of the course. These tests point out with reasonable certainty the cause of the individual difficulties.

There are two tests on each leaf of the same character and of the same degree of difficulty. The first, or odd numbered one, may be used to test for the mastery of a unit; the second may be used for retesting if reteaching has been required.

The reviewer believes that a large saving of time and energy on the part of the teacher could be made by the use of these tests and exercises.

J. M. Kinney.

Adventures In Science, by W. H. Cunningham, High School of Commerce, Boston. Pages v+221. $0.72. Ginn & Co., Boston, Mass.

This volume is a collection of essays in science to be used in the English classes in the high school. It presents to the pupils a series of articles that serve as a pleasant and gradual approach to methods of scientific thinking. The material is representative of scientific achievement and is selected from the writings of experts in their respective fields.

"The Mantis," "Fire and Ants," "The Condor," "Birds and Man," "About Cholera," "The Mastodon," "The Unsolved Problems of Astronomy," "The Influence of Coal Tar on Civilization," "The World of Atoms," "The Method of Scientific Investigation," "What Knowledge Is Of Most Worth," "Æpyorius Island," are the essays selected. Each essay gives a brief account of the life of the writer as well as a set of questions on the text and a list of suggested references for further reading.

This excellent collection of essays should be read by teachers, pupils and the general public. Science teachers should encourage its use in their classes as well as in the English classes. The compiler of this collection deserves praise and commendation for this new undertaking. I. C. D.

Elements of General Science, with Experiments by Otis W. Caldwell, Lincoln School of Teachers College, and W. L. Eikenberry, East Stroudsburg State Normal School, Pennsylvania. Pages xv+600. $1.68. Ginn & Co., Boston, Mass.

This volume is a revision of the widely used book by the same authors with the addition of many new experiments and demonstrations. It also contains considerable new material. There is enough material in the book for a year's work including the laboratory work by the pupils.

Each chapter begins with a set of interesting questions. At the end of each chapter is a set of practical problems of a more or less experimental nature and also a list of test exercises of the completion sentence type. These test exercises are to be used as a summary and review of the material found in the chapter.

The book is attractively "put up," the illustrations are excellent, the subject matter is well distributed, the language is simple but "smooth," teacher "helps" are plentiful, and, taken as a whole, it deserves a very high rating. I. C. D.

Elements of Astronomy, by Edward A. Fath, Professor of Astronomy, Carleton College. pp. viii+307. 14x22.5x2.2 cm. 191 Figures. Cloth. 1926. Price $3.00, McGraw, Hill and Co., Inc.

The subtitle of this text claims to be "A Non-Mathematical Textbook For Use as an Introduction to the Subject in Colleges, Universities, etc., and for the General Reader." The book is an outgrowth of the attempt to present the elements of the science to college freshmen who have had no mathematics beyond high school algebra and geometry, one year each. As a consequence very little use is made of mathematical formulas, the presentational method being mainly the description of results together with principles and methods employed in modern astronomical investigation.

The aforesaid purposes and plan of the undertaking of the author deserve nothing but praise. Furthermore a rather close reading of the text convinces the writer that the author has done his work with admirable skill and with unqualified success. The excellent typography, arrangement of matter on the page and freedom from typographical errors reflect high credit on the publishers.

The writer is so completely in sympathy with the author's attempt to bring the stimulus of this great science into the young collegian's life early in his career and is so impressed with the success of this attempt, that he wishes merely to emphasize that this book would make an excellent text for the late years of strong high schools and would do wonders in whetting the appetite for scientific pursuits. The presentation is admirably adapted to the purposes of the general reader who aspires to keeping informed on the wonderful things going on in this wonderful science, in which so much can be assimilated with so little professional equipment. This sort of text will hasten the day when we shall realize the magnitude of the mistake of the schoolmen in dropping astronomy from the high school course of study.

The author has made good on the purposes and claims of his preface.
G. W. M.

A Numerical Drill Book on Physics, by Lloyd William Taylor, Professor of Physics, Oberlin College. Cloth. Pages viii+95. 13x20 cm. 1926. Ginn and Company. Price $1.00.

Teachers of physics recognize that numerical problem solving is one of the best means of clarifying physical principles and of fixing the subject in the student's mind. This type of work also offers a splendid means of review. Often in the struggle to reduce the size of text books the problem and question pages are eliminated or decreased in number. This little book is designed to supply this deficiency and may be used to supplement any elementary physics course.

Four independent sets of numerical data are given for each problem, thus making it possible to assign to four sets of pupils at the same time or in four successive years without duplication. Teachers will welcome the book as a time saver in making assignments, and students preparing for competitive examination will find it helpful. Four-place tables of trigonometric functions and logarithms are included. G. W. W.

Experimental Science, I Physics, Section IV Heat, Section V Light, Section VI Sound, by S. E. Brown, Headmaster of Liverpool Collegiate School. Cloth. 360 pp. 12x18 cm. 1921. Cambridge University Press. Price $2.50.

This book, together with two other volumes, one on Measurement, Hydrostatics and Mechanics and the other on Electricity and Magnetism, make up an elementary text-book of Physics. Since the amount of material included in each volume is sufficient for a full year or more and considerable use is made of mathematical theory, the book would not be suitable as a regular text book in the secondary schools of the United States; but its wealth of material, good illustrations, and numerous lists of questions and problems fit it admirably for junior college classes. The more able high school students will be pleased with it as a supplementary text. G. W. W.

How to Teach General Science, by J. O. Frank, Professor of Science Education in the Wisconsin State Normal School at Oshkosh, and edited by S. R. Powers, Associate Professor of Natural Science in Teachers College, Columbia University. Cloth. Pages xii+240. 13x20 cm. 1926. P. Blakiston's Son and Co. Price $2.00.

This valuable contribution to the literature of secondary education aims to assist teachers of general science in locating all sorts of aids in the presentation and study of this somewhat new and unorganized subject. The first three chapters present briefly the historical background and the development of the subject. This is followed by a statement of criticism of general science and the methods of teaching it. Aims, subject matter, selection of text books, supervised study, and laboratory and class-room technique come in for a few pages each. Chapter XIV suggests methods of maintaining interest and Chapter XV discusses the measurement of result.

It is not the intention of the author to develop anything new but to make available the contributions of his predecessors and contemporaries. The carefully selected references at the close of each chapter and the lists of available teaching aids are strong features of the book.

G. W. W.

Investigations in the Teaching of Science, by Francis D. Curtis, Assistant Professor of the Teaching of Science, University of Michigan, and Head of the Department of Science in the University High School. Cloth. pp. xvii+341. 13x19 1-2 cm. P. Blakiston's Son & Co. Price $2.50.

The body of this book consists of digests of twenty-six learning studies and forty-four curricular studies in science published in the twenty-year period from 1905 to 1925. In each digest three things are clearly stated—the problem, the method used, and the findings. This plan makes the book a valuable one for the teacher or supervisor of science. It gives him the essentials of many studies for a minimum expenditure of time and effort. A twenty page section of questions and problems relating to the studies provide valuable teaching helps, thus making it a suitable textbook for teacher-training classes in colleges and normal schools.

G. W. W.

Field Notes on Gall-Inhabiting Cynipid Wasps with Description of New Species. Lewis H. Weld of the Bureau of Entomology, U. S. Dept. of Agriculture. 131 pp. with 46 illustrations. 1926. United States Government Printing Office.

This paper deals with the true gall flies of the order Hymenoptera, containing descriptions of 53 new species of which all but two are from the United States. New and interesting observations concerning these insects are given, together with directions for collecting and rearing the flies of the Cynipid galls for purposes of study. Most of the illustrations are from photographs. J. C. I.

Outlines of Comparative Anatomy of Vertebrates, Third edition, by J. S. Kingsley, Professor of Zoology, Emeritus, University of Illinois. pp. x+470. 15x23 cm. with 435 illustrations. 1926. P. Blakiston's Sons, Philadelphia.

The former editions of this text and reference have been standard for so many years that a detailed description of general plan is unnecessary. Numerous changes have been made in this third revision and portions

have been rewritten. The bibliography has been brought up to date and a number of figures have been added. Embryology is retained as the basis. The author does not attempt to describe the structure of any species in detail. The treatment is rather an outline of the general morphology of all vertebrates. J. C. I.

Modern Biology: Its Human Interests, by Harry Dwight Waggoner, Professor of Biology, Western Illinois State Teachers' College, Macomb. pp. vii+482. 13.3x20.3 cm., with 242 illustrations. 1926. D. C. Heath and Company.

As the title indicates, this text appeals to the human interests and hence is a suitable text for the general student. Scientific fact is stated in a matter-of-fact way without unnecessary technical frills. While the book was evidently written for use in high school classes it could be made the basis for an excellent introductory general course in biology in certain college classes. Part one, 164 pages, deals with seed plants. Part two, 122 pages, treats of spore plants including material on bacteria and disease. Part three, 99 pages, takes up nutrition and heredity in man. Part four, 113 pages, is devoted to animals and a discussion of the interrelation of animals and plants. The style of the book recommends it, not only as a text, but for reference and general reading as well. J. C. I.

A Laboratory Manual for Elementary Zoology, by Libbie Henrietta Hyman, the University of Chicago. pp. xviii+182. 17x25.2 cm. Second edition. 1926. The University of Chicago Press.

Eight pages are devoted to general directions for the guidance of students as an aid in the development of a technique. This is a valuable feature of the manual. The writer of this review has used the earlier edition of the book with beginning college classes in general zoology and heartily approves of the general plan and context of the outline. The directions are helpful in getting the student to make personal observations of the laboratory material so that a degree of independence is gradually developed. The outline contemplates more than a study of animals but it includes a study of biological principles as illustrated by animals. The study begins with a general survey of an animal, using the frog as a suitable animal for this study. Then follows an experimental treatment of general physiology and properties of living matter. The cell embryology and heredity are taken up in order and then follows treatments of the various phyla using type animals. An appendix is added, giving practical suggestions with regard to preparing and handling the materials of the course. The course offers more work than can be done in one quarter or even in a semester, but that is not an objectionable feature as it permits a selection of material to suit local conditions, to some extent. The treatment is pedagogical, scientific and well-proportioned. J. C. I.

Analytic Functions of a Complex Variable, by D. R. Curtiss, Professor of Mathematics, Northwestern University. pp. 173. 13.5x19.5 cm. 1926. $2.00. Chicago: Open Court Publishing Co.

This volume is the second one of the Carns Monographs. The ability to read it presupposes an acquaintance with elementary differential and integral calculus.

The literature on the subject of the theory of functions of a complex variable is voluminous. This book has been written to present the fundamental principles. Many references are given so that one may get a broader view of the subject if he desires. J. M. Kinney.

Algebra, by W. R. Longley, Professor of Mathematics, Yale University, and H. B. Marsh, Head of the Department of Mathematics, Technical High School and Springfield Junior College, Springfield, Massachusetts. pp. 577. 13.5x19.5 cm. 1926. New York: The Macmillan Company.

This book has been written for the use of secondary schools. It includes such topics as functions, trigonometric ratios, logarithms, the progressions, and the binomial theorem. Some of the outstanding features claimed by the authors are the following: carefully selected material; clear explanations; an easy approach to new topics through well graded steps and exercises; a large amount of drill material; exclusion of unnecessary technique; a large number of verbal problems; a new and interesting treatment of functions and graphs and ratio, proportion, and variation; numerous cuts and illustrations; and large type for easy reading.

J. M. Kinney.